

GROUNDWATER COMPLIANCE PLAN APPLICATION

DENKA CHEMICAL CORPORATION
HOUSTON PLANT

Submitted to the
TEXAS DEPARTMENT OF WATER RESOURCES

Prepared by
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March 1985

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FOR DEPARTMENT USE ONLY

Executive Director
Texas Department of Water Resources
Attn: Permit Control and Reports Section
P.O. Box 13087, Capitol Station
Austin, Texas 78711

Application No:
Compliance Plan No. CP:
Administrative Review By:
Administratively Complete:
Copies Sent:

GROUND WATER COMPLIANCE PLAN APPLICATION

- Part 1 INVESTIGATION REPORT (Compliance Monitoring Program)
Part 2 ALTERNATE CONCENTRATION
Part 3 INVESTIGATION REPORT (Corrective Action Program)

I. GENERAL INFORMATION

A. Applicant: Denka Chemical Corporation
(Individual, Corporation, or Other Legal Entity Name)

Address: 8701 Park Place Boulevard

City: Houston State: TX Zip Code: 77017

Telephone Number: 713/477-8821

If the application is submitted on behalf of a corporation, please
identify the Charter Number as recorded with the Office of the
Secretary of State for Texas. 041003
(Charter Number)

- B. 1. List those persons or firms, including a complete mailing
address and telephone number, authorized to act for the
applicant during the processing of the application.
Robert E. Hinkson, Quality Assurance Manager
Denka Chemical Corporation
8701 Park Place Boulevard
Houston, TX 77017 Ph: 713/477-8821
2. If the application is submitted by a corporation or by a
person residing out of state, the applicant must designate an
Agent in Service or Agent of Service and provide a complete
mailing address for the agent. The agent must be a Texas
resident.
N/A
3. List the individual and his/her mailing address that will be
responsible for causing notice to be published in the
newspaper.
Same as No. 1 above.

County: Harris

certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe the submitted information is true, accurate and complete. I am aware there are significant penalties for submitting false information, including the possibility of civil penalty and criminal fines.

Signature: Marianne W. (W.) Date: 3/20/85

TO BE COMPLETED BY THE APPLICANT IF THE APPLICATION IS SIGNED BY AN AGENT FOR THE APPLICANT.

I _____ hereby designate _____ as my agent and hereby authorize said agent to sign any application, submit additional information as may be requested by the Department, and/or appear for me at any hearing or before the Texas Water Commission in conjunction with this request for a Texas Water Code or Texas Solid Waste Disposal Act permit. I further understand that I am responsible for the contents of this application, for oral statements given by my agent in support of the application, and for compliance with the terms and conditions of any plan which might be issued based upon this application.

Printed or Typed Name of Applicant
or Principal Executive Officer

Signature

SUBSCRIBED AND SWORN to before me by the said

_____ on this _____ day of _____, 19____.

My commission expires on the _____ day of _____, 19____.

(Seal)

Notary Public in and for

County, Texas

C. Facility for Which Application is Submitted: _____

Houston location

TDWR Registration No.: SW31052 EPA I.D. No.: TXD084972777

County: Harris

I, Marvin Z. Waskow, President
(Name) (Title)

certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe the submitted information is true, accurate and complete. I am aware there are significant penalties for submitting false information, including the possibility of civil penalty and criminal fines.

Signature: _____ Date: _____

TO BE COMPLETED BY THE APPLICANT IF THE APPLICATION IS SIGNED BY AN AGENT FOR THE APPLICANT.

I _____ hereby designate _____ as my agent and hereby authorize said agent to sign any application, submit additional information as may be requested by the Department, and/or appear for me at any hearing or before the Texas Water Commission in conjunction with this request for a Texas Water Code or Texas Solid Waste Disposal Act permit. I further understand that I am responsible for the contents of this application, for oral statements given by my agent in support of the application, and for compliance with the terms and conditions of any plan which might be issued based upon this application.

Printed or Typed Name of Applicant
or Principal Executive Officer

Signature

SUBSCRIBED AND SWORN to before me by the said

_____ on this _____ day of _____, 19____.

My commission expires on the _____ day of _____, 19____.

(Seal)

Notary Public in and for

_____ County, Texas

PART 1

INVESTIGATION REPORT - COMPLIANCE MONITORING PROGRAM

INTRODUCTION

Part 1 of this Groundwater Compliance Plan Application is an investigation report describing a proposed compliance monitoring program for the Denka Chemical Corporation's Houston facility. The report includes information required by Section 335.464(8)(D) of the Texas Administrative Code (TAC) in response to a confirmed statistical increase of indicator parameters in groundwater underlying the facility. The report is organized into sections corresponding to numbered items on the TDWR application instructions. Information is provided relative to:

- (1) locations of waste management and groundwater monitoring systems, including a facility plot plan;
- (2) waste sources and characteristics;
- (3) facility history;
- (4) reported concentrations, background levels, and detection limits of hazardous constituents identified in the groundwater; and
- (5) the proposed system compliance conditions, and procedures to be incorporated in the facility's compliance monitoring plan, including proposed changes to the facility's existing groundwater monitoring program.

As a separate section, Part 2 of this application presents data and information to justify a variance sought by the applicant in accordance with Sections 335.460(b) and 335.464(8)(E)(i) of the TAC. Alternate concentration limits are proposed for benzene and toluene.

An emergency feasibility plan for a corrective action program is not included with this application since a variance is sought with respect to all hazardous constituents identified in groundwater underlying the facility, as provided for in Section 335.464(8)(E)(ii)(II).

WASTE MANAGEMENT AND GROUNDWATER MONITORING SYSTEMS

The Denka Houston facility currently has five regulated hazardous waste management (HWM) units. These are identified as tanks 128 and 175, the maleic pond, the storm water pond, and the Imhoff pond. In addition, the plant has several nonregulated units which are used for wastewater treatment. These include tanks 412 and 413, three parallel oxidation ponds (activated sludge units), the solar pond, and the anaerobic pond. The oxidation ponds are located south of the actual Denka property and are owned and operated jointly by Denka and an adjoining plant, Texas Petrochemicals Corporation (formerly Petro-Tex). These waste management units are indicated clearly on the facility plot plan, included with this application in an attached map pocket.

The only known inactive or closed on-site industrial solid waste or wastewater facility is the upper section of the maleic pond. This facility is also indicated on the plot plan.

The groundwater monitoring (GWM) wells are also identified individually by number on the plot plan. They include well numbers 1, 2, 3, 4, 5a, 21, and 22.

The proposed point of compliance is an imaginary line which intersects downgradient GWM wells 1, 2, and 5a. These wells are completed in the uppermost water-bearing unit and are the ones which have demonstrated contamination. This proposed point of compliance is parallel and adjacent to Sims Bayou which is the primary local watercourse of interest.

WASTE CONTRIBUTIONS

A comprehensive list of the wastes and their sources for each waste management facility is provided in Table 1.1. Also shown are any Appendix VIII constituents which may be present in each waste stream. It is significant to note that none of the Appendix VIII constituents identified in Table 1.1 have been found in detectable quantities in any of the groundwater samples collected to date.

FACILITY HISTORY

The general history of each waste management facility is summarized in Table 1.2. All units are active except for the upper section of the maleic

TABLE 1.1
WASTE SOURCES AND POTENTIAL LISTED CONSTITUENTS

Waste Management Facility	Wastes Handled	Process Sources	Potential Appendix VIII Constituents
Maleic Pond Upper Section (closed)	Maleic Wastewater	Maleic Anhydride Plant	Maleic Anhydride
Lower Section	Maleic Wastewater	Maleic Anhydride Plant	Maleic Anhydride
Stormwater Pond	Maleic Wastewater	Maleic Anhydride Plant	Maleic Anhydride
	Contaminated Stormwater	Neoprene Plant	1,4-Dichloro-butene-2
Imhoff Pond	Maleic Wastewater	Maleic Anhydride Plant	Maleic Anhydride
Tanks 128, 175	Chlorinated C ₄ -Hydrocarbons	Neoprene Monomer Plant	1,4-Dichloro-butene-2
Tanks 412, 413	Aqueous Neoprene Wastewater	Neoprene Monomer Plant	1,4-Dichloro-butene-2 Crotonaldehyde
Oxidation Ponds	Maleic Wastewater	Maleic Anhydride	Maleic Anhydride
	Aqueous Neoprene Wastewater	Neoprene Monomer Plant	1,4-Dichloro-butene-2, Crotonaldehyde
	Neoprene Washwater	Neoprene Finishing Plant	None
	API Wastewater	Texas Petrochemicals	Formaldehyde, Acrolein
	Oxo Condensate	Texas Petrochemicals	Formaldehyde, Acrolein
	Oxo Scrubber Waste	Texas Petrochemicals	Formaldehyde, Acrolein
Anaerobic Pond	Excess Activated Sludge (Infrequent basis)	Oxidation Ponds	None
Solar Pond	Noncontaminated Stormwater	Adjacent Nonprocess Areas	None
	Emergency Overflow	Texas Petrochemicals Alum Clarifiers	None

TABLE 1.2
FACILITY HISTORICAL SUMMARY

Waste Management Facility	Year Constructed	Year First Used	Year Closed	Potential Conduits
Maleic Pond				
Upper Section	1963	1963	1981	None Known
Lower Section	1963	1963	Active	None Known
Stormwater Pond	1975	1975	Active	None Known
Imhoff Pond	1963	1963	Active	None Known
Tanks 128, 175	1969	1970	Active	None Known
Tanks 412, 413	1969	1970	Active	None Known
Oxidation Ponds				
North	1965	1965	Active	None Known
Middle	1965	1965	Active	None Known
South	1970	1970	Active	None Known
Anaerobic Pond	1963	1963	Active	None Known
Solar Pond	1963	1963	Active	None Known

pond which was closed in 1981. There are no known abandoned wells, unplugged boreholes, or other similar features which could serve as vertical conduits for contaminants. The only significant surficial feature near the waste management area is Sims Bayou along the west side. Topographic relief from near the center of the plant to the bayou is about 20 feet.

CONCENTRATIONS OF HAZARDOUS CONSTITUENTS IN GROUNDWATER

Following the 1983 determination that a significant increase of indicator parameters had occurred in the GWM system, Denka resampled all GWM wells and determined through an outside laboratory the concentration of listed Appendix VIII constituents present in the groundwater. The complete tabulation of results is presented in an appendix to this application. Table 1.3 summarizes the concentrations of the constituents found in all seven GWM wells. As discussed in the Groundwater Quality Assessment Plan Report of First Determination (Geo Associates, September 1984), the presence of trichloroethylene in the two shallow upgradient wells is consistent with high TOX concentrations noted in upgradient wells from previous monitoring results. The source of TOX is believed to be off-site.

Three Appendix VIII constituents were noted in two shallow downgradient wells which were not found in upgradient wells. Benzene and toluene were identified in well 2 at concentrations of 24 ug/l and 39 ug/l, respectively. 1,1,2,2-tetrachloroethane was found in well 5a at the method detection limit concentration of 10 ug/l.

Wells 2, 4, 5a, and 22 showed detectable levels of bis(2-ethylhexyl)-phthalate. This compound is often present in samples taken from well casings made of PVC and generally is viewed as a material-derived contaminant. Similarly, the trace concentration (10 ug/l) of methylene chloride found in upgradient well 4 is probably attributable to analytical error since methylene chloride is a common laboratory solvent used in sample preparation and is not handled at the Denka plant.

Of all the constituents identified, only benzene and toluene are possibly related to the Denka plant operations. Benzene was used as a feedstock for the maleic process from 1963 to 1981 and may have been present in the maleic wastewater, but only in trace amounts up to the species solubility. Similarly, toluene has been and is currently used as process

TABLE 1.3
CONCENTRATION OF APPENDIX VIII CONSTITUENTS
IDENTIFIED IN DENKA GWM WELLS

Compound	Well						
	Up Gradient			Down Gradient			
	3	4	21	1	2	5a	22
Benzene	-	-	-	-	24	-	-
Toluene	-	-	-	-	39	-	-
1,1,2,2-Tetra- chloroethane	-	-	-	-	-	10	-
Trichloroethylene	240	240	-	-	240	-	-
Methylene Chloride	-	10	-	-	-	-	-
Bis (2-Ethylhexyl) Phthalate	-	52	-	-	27	15	81

Notes: All concentrations are expressed in micrograms per liter (ppb).
Data is based upon sampling conducted December 1983.
"-" indicates below method detection limit.

feedstock but would be present in a waste stream only in trace amounts. It is handled minimally within the process area in drum quantities and is never generated as a nonaqueous waste.

For each of the Appendix VIII constituents identified in groundwater underlying the Denka facility, background levels and detection limits are presented in Table 1.4. The background levels shown are based on the available upgradient well data, including wells 3 and 4. Well 21 was not included since it and well 22 were screened into a deeper sand zone which was determined in the assessment program to probably not be hydraulically connected to the uppermost sand.

PROPOSED GROUNDWATER MONITORING PROGRAM

Purpose

In accordance with this compliance plan application requirements and Section 335.465 of the TAC, Denka Chemical Corporation has prepared a Compliance Monitoring Program to assure the detection of hazardous constituents in groundwater resulting from Denka's operations. The program addresses modifications to the current groundwater monitoring system and procedures and establishes the required compliance conditions.

Proposed Groundwater Protection Standard

The proposed hazardous constituents are those Appendix VIII constituents which have been detected in downgradient wells at the Denka facility. They include benzene, toluene, 1,1,2,2-tetrachloroethane and trichloroethylene. An exemption is requested for bis(2-ethylhexyl)phthalate because this compound, which is not used or generated at the Denka plant, appears to be a monitoring system contaminant derived from the PVC well casing or sampler. Indicator parameters will continue to be monitored as part of the existing detection monitoring program.

The proposed concentration limits are 500 ug/l for benzene and 2,000 ug/l for toluene. The technical basis for these alternate values is presented in Part 2 of this application (Alternate Concentration).

In the case of 1,1,2,2-tetrachloroethane and trichloroethylene, Denka believes that the source of these constituents is off-site, as evidenced by the fact that neither compound is used or generated at the Denka plant and

TABLE 1.4
BACKGROUND LEVELS AND DETECTION LIMITS
FOR APPENDIX VIII CONSTITUENTS
IDENTIFIED IN DENKA GWM WELLS

Appendix VIII Compound	Background Concentration, (ug/l)*		Method Detection Limit (ug/l)
	Single Maximum Determination	Mean of Upgradient Wells	
Benzene	<10	<10	10
Toluene	<10	<10	10
1,1,2,2-Tetra- chloroethane	<10	<10	10
Trichloroethylene	240	240	10
Methylene Chloride	10	<10	10
Bis (2-Ethylhexyl) phthalate	52	<31	10

* Background concentrations are based upon upgradient well data of December 1983. Well No. 21, which was bored as part of the Groundwater Quality Assessment Program, is not included in this determination because it is screened in sands deeper than and not hydraulically connected to the uppermost water bearing unit.

the historical record of high TOX values in the upgradient wells. The Groundwater Quality Assessment Plan Report of First Determination (Geo Associates, September 1984) demonstrated a significant temporal correlation between upgradient and compliance point concentrations of TOX. Pursuant to TAC Section 335.465(3)(A), Denka proposes to establish the concentration limits of 1,1,2,2-tetrachloroethane and trichloroethylene through sampling at upgradient wells each time groundwater is sampled at the compliance point. For a given sampling event, the concentration limit of each of these parameters will be defined by the arithmetic mean of four samples collected simultaneously from upgradient well 3 or 4.

The proposed compliance point is an imaginary line which intersects downgradient wells 1, 2, and 5a as shown on the facility plot plan, which is attached to this application.

The period of compliance will commence upon administrative approval by the TDWR of the facility's compliance monitoring program, and will continue through the active life of the waste management area (including closure). In addition, if Denka becomes obligated to implement a corrective action program which is ongoing at facility closure, the compliance period will be extended until Denka can demonstrate that the groundwater protection standard has not been exceeded for a period of three consecutive years.

Monitoring System

Denka proposes to utilize existing GWM wells in the compliance monitoring program. Wells 3 and 4 will serve as upgradient wells and wells 1, 2, and 5a will monitor groundwater at the compliance point. Wells 21 and 22 are screened in a deeper sand which appears to not be hydraulically connected to the uppermost permeable zone. Wells 21 and 22 will, however, be used to check the potential migration of contaminants to the deeper strata. Construction details of each of these seven wells have been provided in previously submitted documents ("Petro-Tex and Denka Chemical Corporations Groundwater Monitoring Program Phase I," Espey, Huston and Associates, October 1981 and "Groundwater Quality Assessment Plan Report of First Determination," Geo Associates, September 1984).

The waste management area is designated on the facility plot plan, and includes the storm water pond, the Imhoff pond, and both sections of the maleic pond.

Sampling Methods and Frequency

Prior to sampling each well, the free water surface elevation will be measured by noting the depth to the water level and subtracting this value from the land surface elevation.

Samples from the upgradient wells will be collected prior to the downgradient wells in order to minimize the possibility of contaminant transfer between wells. Water samples will be taken from each well by means of a PVC bailer or submersible pump. In order to obtain a representative sample, at least one casing volume of water will be removed and discarded before obtaining a usable sample. After rinsing the composite bucket with well water, sufficient volume will be drawn to fill the composite bucket (approximately three gallons). The composite volume will then be apportioned into pre-labeled quart-size linear polyethylene and glass containers to minimize losses due to sorption to the container walls. All samples will be placed in an ice chest for transport. The bucket and rope or pump tubing will be triple-rinsed before sampling the next well. Any necessary additions for sample preservation will be added either during sample collection or by the laboratory personnel immediately upon receipt if delivery is within two hours of collection. The sample collection personnel will note any unusual odors or appearances of samples at the time of sampling on the field portion of the chain of custody form. The techniques to be used for sample collection, preservation, and analysis are indicated in Table 1.5.

Table 1.6 presents sampling frequencies for the various parameters which require monitoring. Sampling frequency will be quarterly for elevation checks and the Appendix VIII constituents identified to date. The wells will be sampled semiannually for the indicator parameters in accordance with Denka's existing detection monitoring program. As shown in Table 1.6, the groundwater flow rate at the site will be determined annually. Finally, Denka will analyze samples from all downgradient wells annually for all constituents contained in Appendix VIII of 40 CFR Part 261 to determine whether additional hazardous constituents are present in the uppermost aquifer. If other hazardous constituents are found to be present, the facility will determine their concentration in upgradient and

TABLE 1.5
SAMPLE PRESERVATION AND ANALYTICAL METHODS

Parameter	Type of Container	Preservative	Available Method References*
Benzene	Glass, Teflon Cap	Cool to 4°C	SW-8020, 8240; FR-602, 624, 1624
Toluene	Glass, Teflon Cap	Cool to 4°C	SW-8020, 8240; FR-602, 624, 1624
1,1,2,2-Tetra- chloroethane	Glass, Teflon Cap	Cool to 4°C	SW-8010, 8240; FR-601, 624, 1624
Trichloro- ethylene	Glass, Teflon Cap	Cool to 4°C	SW-8010, 8240; FR-601, 624, 1624
Specific Conductivity	Field	None	SM-205, EPA-120.1
pH	Field	None	SM-424, EPA-150.1
TOC	Glass	H ₂ SO ₄ to pH<2	SM-505, EPA-415.1
TOX	Glass	Cool to 4°C	EPA-450.1, SW-9020
Appendix VIII Metals	Polyethylene	HNO ₃ to pH<2	SW, SM, EPA, FR
Appendix VIII Organics	Glass, Teflon Cap	Cool to 4°C	SW, FR

* SW: SW-846 Test Methods for Evaluating Solid Waste, 2nd Edition (1982)
 SM: Standard Methods for the Examination of Water and Wastewater
 EPA: EPA 600/4-79-020 Methods for Chemical Analysis of Water and Wastes
 FR: Federal Register, 40 CFR Part 136 "EPA Regulations on Test Procedures for the Analysis of Pollutants"

TABLE 1.6
GROUNDWATER MONITORING PARAMETERS

Frequency	Parameters	
	Upgradient	Downgradient
Quarterly ¹	<ul style="list-style-type: none"> - 1,1,2,2-Tetrachloroethane* - Trichloroethylene* - Elevation 	<ul style="list-style-type: none"> - 1,1,2,2-Tetrachloroethane* - Trichloroethylene* - Benzene* - Toluene* - Elevation
Semiannually ²	<ul style="list-style-type: none"> - Specific Conductivity* - pH* - TOC* - TOX* 	<ul style="list-style-type: none"> - Specific Conductivity* - pH* - TOC* - TOX*
Annually ³	<ul style="list-style-type: none"> - Flowrate 	<ul style="list-style-type: none"> - Flowrate - Appendix VIII Constituents

* 4-fold sample analysis and statistical work-up required.

¹ TAC 335.465 (3)(A), (4)

² TAC 335.464 (4)

³ TAC 335.465 (5), (6)

downgradient wells in addition to notifying the Executive Director within seven days of the discovery.

Statistical Determination

Indicator parameters will continue to be evaluated using Cochran's Approximation to the Behrens-Fisher Student's t-test. A modification to the existing groundwater monitoring program is that significant increases will be determined at the 0.05 level rather than the 0.01 level, pursuant to TAC 335.463(8)(A)(i).

The method to be used for evaluating significant increases of Appendix VIII constituents over their respective concentration limits in the groundwater will be specified by the Commissioner in the groundwater compliance plan, as outlined in Section 335.463(8)(B). Denka proposes that for a given downgradient well, a significant increase would occur when the mean of the fourfold sample analyses exceeded the concentration limit during any sampling event for a given parameter.

Reporting Requirements

Normal reporting procedures will involve preparing an annual summary of groundwater quality data and groundwater flow rate and direction. This summary will be submitted to the Executive Director prior to January 21 of each year on forms provided by the TDWR, as required by TAC 335.465(13). This annual reporting requirement will be in effect throughout the compliance period.

If Denka determines at any time that the groundwater protection standard is being exceeded at any monitoring well along the compliance point, it will notify the Executive Director of this finding in writing within seven days. Within 180 days of the determination, the facility will submit an investigation report to establish a corrective action program meeting the requirements of Section 335.466.

PART 2

ALTERNATE CONCENTRATION

INTRODUCTION

Part 2 of the application is an information report which provides the technical basis for the proposed alternate concentrations. The report addresses all of the information requested in the TDWR application instructions. In addition to the required information on regulated waste units and characteristics, surface and groundwater hydrology, and waste exposure hazards, additional sections are included to present projected and worst-case environmental impacts and the technical basis for selecting the alternate concentration limits.

The information presented here was drawn upon from a number of sources which are both referenced in the text and later listed in the bibliography.

REGULATED FACILITIES, WASTES, AND CONTAINMENT FEATURES

Of the Appendix VIII hazardous constituents which have been identified in compliance point groundwater at Denka, alternate concentration limits are sought for benzene and toluene. Benzene was used as a feedstock to the maleic process from 1963 until 1981 and has not been handled at the facility since 1981. Toluene continues to be used as a solvent in the manufacturing process for maleic anhydride. Both of these chemical components would have been present conceivably in wastes only as part of the aqueous maleic waste stream in concentrations below their respective aqueous solubilities. Neither constituent has been generated and disposed on-site in bulk form. Because of their possible presence (past presence in the case of benzene) in the maleic wastewater, the regulated hazardous waste units which potentially contain these constituents include the maleic pond, the storm water pond, and the Imhoff pond. These facilities are all contained within the same waste management area. The alternate concentration limit sought for benzene is 500 ug/l. The alternate concentration limit sought for toluene is 2,000 ug/l. The technical justification for these values is provided in a later section of this part of the compliance plan application.

Table 2.1 identifies the waste types, amounts, and characteristics within each of the regulated units which may contain the constituents for which alternate concentrations are sought. The complete chemical composition of the maleic waste stream has not been determined. Such a determination historically has been impeded by the lack of a reliable method for the analysis of maleic acid. The quantitative estimates given for benzene and toluene are practical upper limits, corresponding to their solubilities in the water phase. It is believed that the actual concentrations of these species in the regulated units are much lower.

Containment features associated with the regulated units identified above are shown in Table 2.2. The Imhoff pond and both sections of the maleic pond are believed to have been excavated in natural clay beds. The upper section of the maleic pond has been backfilled and topped with a graded clay cap and grass cover. When the storm water pond was excavated in 1975, clay fill was laid down and compacted over any sandy or silty areas encountered. A freeboard of two to four feet is maintained in these ponds. Excess wastewater from the maleic pond is sent to the storm water pond for emergency holding.

GROUNDWATER HYDROLOGY

Regional and Site-specific Hydrogeology

The Denka facility, located within the Gulf Coastal Plain of Texas, is situated upon the outcropping Beaumont clay formation of Pleistocene age. Table 2.3 identifies the major subsurface formations. The Beaumont is composed of mostly clay, silt, and sand interbeds and makes up most of the Upper Chicot aquifer. The Chicot aquifer has about 700 feet of thickness beneath the site, including a more significant Lower unit which makes up the deeper 400 to 500 feet of the aquifer. The Lower Chicot is predominantly sand, shale, and clay of the Pleistocene age Montgomery, Bentley, and Willis sand formations.

Beneath these stratigraphic units, the upper Pliocene epoch and hydraulic conductivity differences act to form a common boundary for the hydrologic unit called the Evangeline. The Evangeline aquifer (1,800 feet thick), although much deeper than the Chicot, is the most sought after and utilized water-bearing zone in the Houston industrial sector. Past heavy

TABLE 2.1
SUMMARY OF WASTES WITHIN REGULATED UNITS
WHICH MAY CONTAIN ALTERNATE CONCENTRATION CONSTITUENTS

Regulated Unit	Waste Type	Waste Amount	Chemical Characteristics
Maleic Pond (lower)	Aqueous Wastestream from Maleic Plant	1,200,000 gal. (unit capacity)	Maleic Content Undetermined ¹ pH 2.2-3.0 Conductivity 6100 umhos/cm TOC 2400 mg/l TOX 8.1 mg/l Oil & Grease 5 mg/l Benzene <1780 mg/l ² Toluene <435 mg/l ²
Stormwater Pond	Aqueous Wastestream from Maleic Plant via Maleic Pond	1,500,000 gal. (unit capacity)	Maleic Content Undetermined ¹ pH 2.2-10.2 Conductivity 5600 umhos/cm TOC 260 mg/l TOX 27 mg/l Oil & Grease 16 mg/l Benzene <1780 mg/l ² Toluene <435 mg/l ²
	and		
	Contaminated Stormwater from Neoprene plant	Contingent upon Rainfall	
Imhoff Pond	Aqueous Wastestream from Maleic Plant	250,000 gal. (unit capacity)	Maleic Content Undetermined ¹ pH 2.2-3.0 Conductivity 4800 umhos/cm TOC 920 mg/l TOX 23 mg/l Oil & Grease 61 mg/l Benzene <1780 mg/l ² Toluene <435 mg/l ²

¹ Analytical method for maleic content is undeveloped.

² Aqueous solubility shown - actual concentration is much less.

TABLE 2.2

WASTE CONTAINMENT FEATURES FOR REGULATED UNITS
WHICH MAY CONTAIN ALTERNATE CONCENTRATION CONSTITUENTS

Regulated Unit	Containment Features
Maleic Pond - Upper (closed)	Underlain by natural clay; two foot clay cap; crowned; grass cover
Maleic Pond - Lower	Underlain by natural clay; 2-4' freeboard maintained; excess sent to Stormwater Pond
Stormwater Pond	Underlain by natural and applied clay; 2-4' freeboard maintained
Imhoff Pond	Underlain by natural clay; 2-4' freeboard maintained; excess sent to Stormwater Pond

TABLE 2.3

GEOLOGIC AND HYDROLOGIC UNITS USED IN THIS REPORT
AND IN RECENT REPORTS IN NEARBY AREAS

SYSTEM	SERIES	HARDER (1960)		ROGERS AND CALANDRO (1965)		RECENT TEXAS REPORTS	BAKER (1964)	WESSELMAN (1965)	WOOD AND GAB-RYSCH (1965)	1/ HYDROLOGIC UNIT	THIS REPORT HYDROLOGIC UNIT
Quaternary	Holocene	FORMATION	HYDROLOGIC UNIT	GROUP OR FORMATION	HYDROLOGIC UNIT	FORMATION	HYDROLOGIC UNIT	HYDROLOGIC UNIT	HYDROLOGIC UNIT		
		Alluvium		Alluvium	Alluvium	Alluvium 2/			Beaumont		Upper Chicot
		Prairie Formation	Chicot shallow	Stream terrace and upland deposits	Stream terrace and upland deposits	Beaumont Clay		Upper aquifer		Chicot aquifer	Chicot
		Montgomery Formation	"200 foot"			Lissie Formation		Middle aquifer	Alta Loma Sand of Rose (1943)		
	Pleistocene	Bentley Formation	"500 foot"			Montgomery Formation 3/					Chicot aquifer
Tertiary		Willanna Formation	"700 foot"			Bentley Formation 3/					Lower Chicot
						Willis Sand 4/					Chicot
		Foley Formation	Evangelina aquifer	Fleming Formation of Kennedy (1892)	Blounts Creek Member of Flisk (1940)	Gollad Sand		Lower aquifer	Heavily pumped layer	Evangelina aquifer	Evangelina aquifer
		Fleming Formation of Flisk (1940)			Castor Creek Member of Flisk (1940)						
	Pliocene					Fleming Formation 5/					
	Holocene								Zone 2	Burkeville aquiclude	Burkeville aquiclude

1/ Wesselman (1967), Tarver (1968a and 1968b), Anders and others (1968), Sandeen (1968), and Wilson (1967).

2/ Floodplain and terrace deposits in Baker (1964).

3/ Lissie Formation in Baker (1964), Wesselman (1965 and 1967), Sandeen (1968), and Anders and others (1968); and Bentley and Montgomery Formations in Wilson (1967) and Tarver (1968a and 1968b).

4/ Pliocene (?).

5/ Shown as the Lagarto Clay of Miocene (?) age in Baker (1964) and Wesselman (1967).

SOURCE: Wesselman, 1971.

pumpage from within the Chicot has made its production capabilities less desirable. To a lesser extent, the Evangeline has had a similar trend.

The Burkeville confining layer, composed of silts, clays, and some sands, underlies the Evangeline and functions to retard the exchange of water between the Evangeline and the deeper Jasper aquifer. The Oakville sandstone formation of Miocene age makes up a large part of the Jasper. The Jasper aquifer is not utilized to a significant degree in the Houston area due to its great depth and, consequently, highly mineralized waters. Lower pre-Miocene sediments do not function as a groundwater source in Houston.

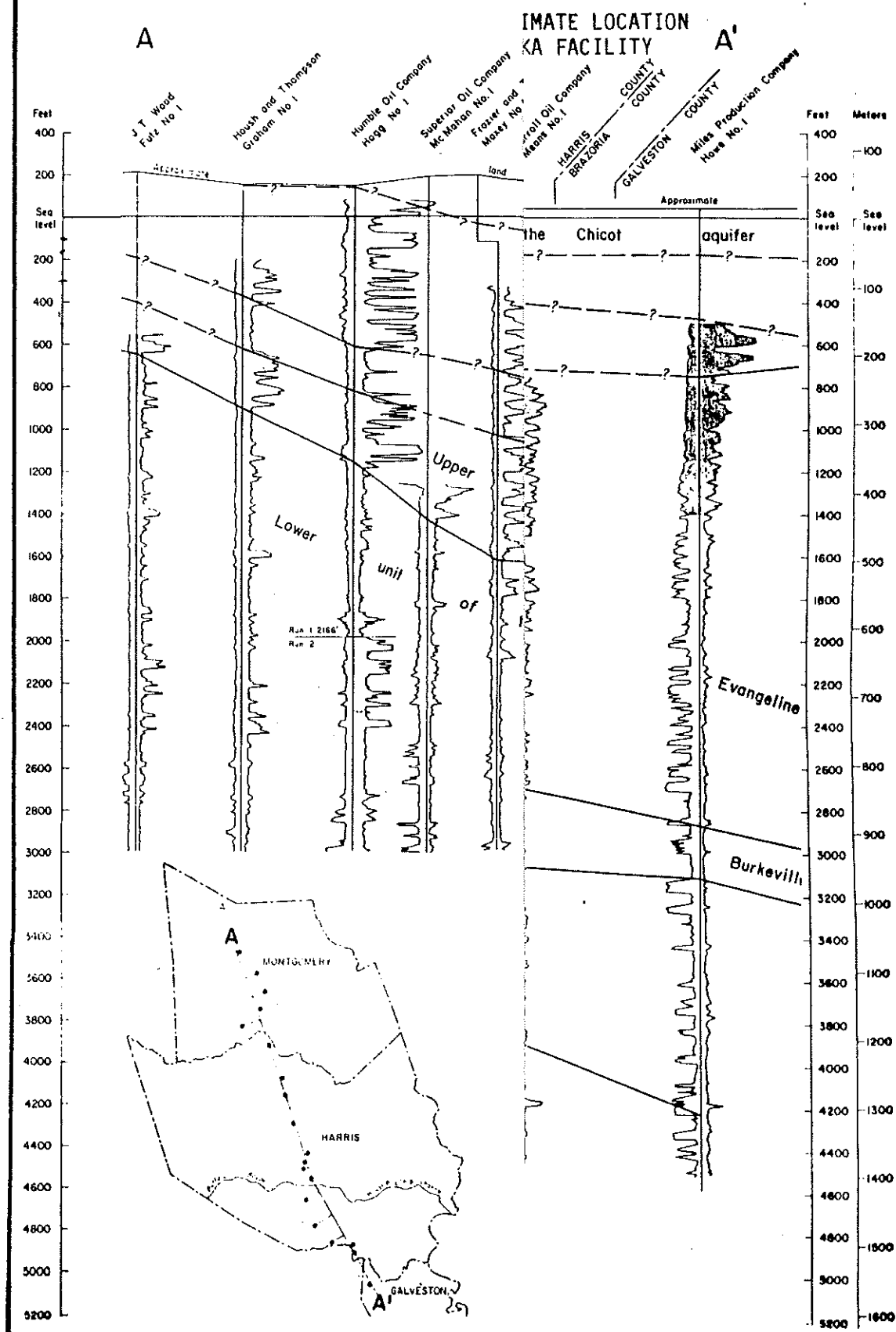
As shown in Figure 2.1, the stratigraphic units that compose these aquifers dip to the south and southeast at increasingly greater angles as a result of increased sediment overburden. A noticeable thickening of the younger or near-surface strata results from sedimentation (deposition) at the time of subsidence. Subsidence takes place due to overburden pressures and heavy groundwater withdrawal.

Land surface subsidence is detailed in a recent study (Gabrysch, 1984) which documents a surface elevation drop at the Denka site of seven to eight feet since 1906 (until 1978). The most recent drop from 1973 until 1978 was just over 0.75 feet in total. The rate of subsidence has been projected to decline in the Houston area (Muller and Price, 1979) with an elevation drop of 0 to 0.2 additional feet expected by the year 2020.

Land subsidence within the Texas Coastal Plain is relative to active surface and subsurface faulting. A major fault system located about three miles south of the Denka facility trends northeast and southwest (source: Barnes, 1968, revised 1982). The closest located fault extends northward to within 0.8 miles of the southern perimeter of Denka out to the south-southeast. As noted in geologic surveys, there is evidence of local faulting which passes through or within the area of the nearby U.S.S. Chemicals plant about 0.4 to 0.7 miles to the east of Denka.

The Upper Chicot aquifer is that which has been penetrated and monitored in the seven wells acting to monitor the Denka waste facility area. The 1981 report of the groundwater monitoring program prepared by Espey, Huston and Associates (EH&A) and the 1984 Groundwater Quality Assessment

FIGURE 2-1 REGIONAL HYDROLOGIC CROSS-SECTION



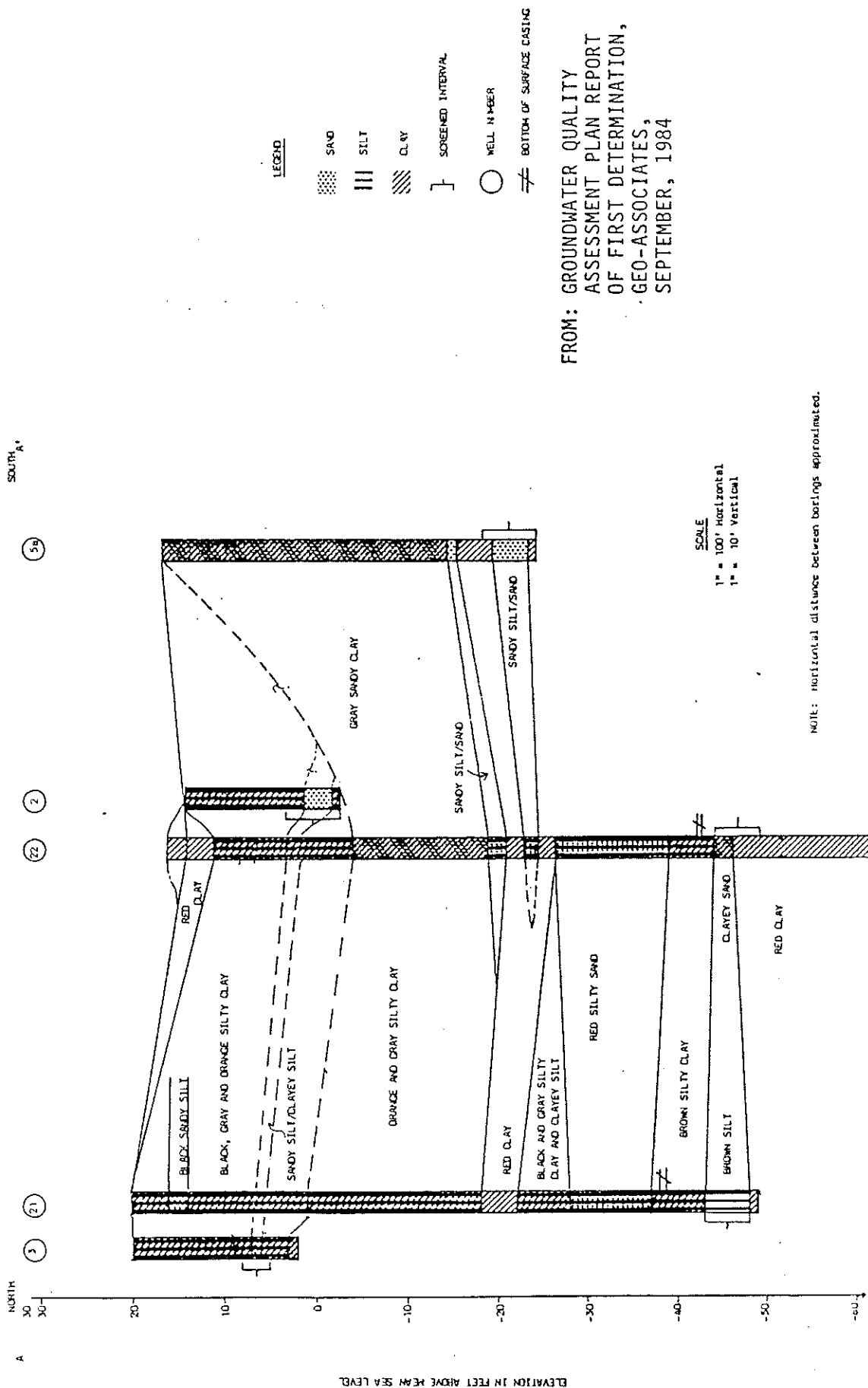
Plan Report of First Determination, prepared by Geo Associates, provide characterization of the site-specific conditions relating to hydrogeology at the Denka plant. The EH&A study reveals data and conclusions from boreholes and piezometers that were spaced over the Petro-Tex and Denka plant areas. All boring logs, associated geotechnical tests, a groundwater contour map, an aquifer surface map, hydrographs of wells, and five cross-sections were presented. The Geo Associates report presents groundwater quality data and assessments relating to well tests and water level readings of five monitoring wells installed by EH&A in the detection monitoring program and of two additional deeper wells installed by Geo Associates. Also included is a cross-section more specific to the waste facility, reproduced here as Figure 2.2.

At the present time, three separate permeable zones have been penetrated and defined within the Upper Chicot aquifer immediately underlying the site. The shallowest zone, a thin, sandy silt, has been monitored since 1982 by wells 1, 2, 3, 4, and possibly by 5a. This shallow silt, which is from one to eight feet in thickness, is found at variable depths from 18 feet above to 19 feet below mean sea level (msl) and may consist of one divergent or several discontinuous zones.

Two deeper permeable units were encountered down to 70 feet in depth during the drilling of the Geo Associates-installed wells, numbers 21 and 22. The shallower of the two deeper units consists of red silty sand which appears to be continuous from well numbers 21 to 22 at a depth of approximately 30 feet below msl. This "El-30 ft sand" is very dense and could not be penetrated completely during the Standard Penetration Test performed in both wells. The lowermost permeable zone investigated to date is a silt and sand stratum at about 45 feet below msl. This "El-45 ft. sand," screened into wells 21 and 22, does not appear to be connected hydraulically to any of the shallower zones except possibly the El-30 ft. sand to a minor degree because of its close proximity. Water quality data and well tests have supported this conclusion.

The majority of the shallowest silt and sand zone is internally discontinuous, but because of the frequency of the permeable features with depth, it is likely that these sand lenses are connected hydraulically. The separating clay strata between the near-surface silts and the El-30 ft.

FIGURE 2-2
SITE-SPECIFIC GEOLOGIC CROSS-SECTION A-A'



sand zone are generally low to moderate in undrained shear strength (0.2 to 0.8 tons per square foot) except within the very stiff (red, orange, and gray) clays and silty clays which occur five to 20 feet above the E1-30 ft sand. These harder, more plastic clays were tested for vertical permeabilities in the EHA study and for undrained shear strength in both studies. The coefficient of permeability was on the order of 10^{-8} cm/sec in a more consolidated sandy clay, while shear strength ranged from 1.0 to greater than 1.35 tons per square foot in all boreholes where these deeper clays were penetrated. Vertical permeabilities on shallower, intermediately consolidated clays were measured at 1.75×10^{-9} and 1.98×10^{-9} cm/sec.

Aquifer Characteristics

Both the Upper and Lower Chicot aquifers and the underlying Evangeline units are confined as a result of thick clay interbeds and by the Burkeville Confining Layer. The overlying interbeds of clay tend to trap groundwater recharging from higher altitude recharge areas to the north and northwest of Houston creating an upward potentiometric (pressure) head, while the Burkeville, as discussed previously, retards downward leakage, from the Evangeline into deeper aquifers.

The basis for separating the Chicot aquifer from the underlying Evangeline aquifer is primarily a difference in hydraulic conductivity which partly causes differences in the two aquifers' potentiometric surface elevations. The upper and lower units of the Chicot are separated in a similar way except in the northern part of the Houston area where their differences are not seen.

The individual sand beds and regional aquifers exist under leaky artesian conditions where groundwater moves slowly through continuous clay and silt layers between permeable beds or moves within connecting permeable units in a more lateral motion.

General site thicknesses and depths of each major hydrologic unit have been described previously in the regional and site-specific hydrogeology section and are supplemented by Table 2.3 and Figure 2.1.

Formation characteristics of the Chicot and Evangeline aquifers in the Houston area are detailed in the Texas Water Development Board Report 190 (Jorgensen, 1975).

The hydraulic properties of the aquifers were determined through tests which measured certain parameters with respect to water-bearing and transmitting properties which include: storage coefficient (volume of water derived per aquifer base area multiplied by the vertical displacement of the piezometric surface), transmissivity (coefficient of permeability multiplied by the saturated aquifer thickness) in gallons per day (gpd) per foot, and coefficient of permeability (discharge multiplied by the length of flow path divided by cross-sectional area multiplied by final pressure subtracted from initial pressure) in gpd per square foot. The yield and water table drawdown of a well may be predicted utilizing these coefficients.

The transmissivity of the Lower Chicot aquifer ranges from zero to about 150,000 gpd per foot with a value in the site area of around 35,000 gpd per foot. The storage coefficient in the Chicot ranges from 0.0004 to 0.20 and is generally 0.0004 in the site area. Permeability coefficients range from near zero to 600 gpd per square foot and are not known for the lower portion of the Chicot at the site.

The transmissivity of the Evangeline aquifer ranges from less than 37,500 to about 115,000 gpd per foot with an approximate value in the site area of 75,000 to 95,000 gpd per foot. The Evangeline storage coefficient ranges from about 0.0005 to 0.0002 under artesian conditions and is generally 0.0005 in the area of the site. The coefficient of permeability averages about 250 gpd per square foot in the Evangeline in the Houston district.

More site-specific in situ permeability tests (slug tests) were performed on wells 2, 3, and 5a which determined "shallow silt" coefficients of permeability or hydraulic conductivities to be 2.2×10^{-3} , 4.7×10^{-3} and 1.1×10^{-3} cm/sec, respectively. These values corresponding to 47, 100, and 23 gpd per square foot are low when compared to the aforementioned range for the Chicot. Hydraulic gradients within this aquifer range from 0.0011 to 0.0095 with a flow direction generally toward Sims Bayou to the southwest. The hydraulic gradient appears to increase with proximity to Sims Bayou. Flow directions within the lower part of the Chicot and in the Evangeline are west-southwest and west-northwest, respectively. A heavy pumping influence, however, in this industrial area has created a cone of

depression centered around the site area which could cause variance in the deeper regional aquifer flow directions (Gabrysch, 1984).

A recharge/discharge relationship within lenses of the shallow silt aquifer was demonstrated during the EH&A groundwater study in 1981 which evaluated data from 23 piezometers. Several groundwater mounding features were noted from water level elevations within the piezometers which were screened into the shallow silt unit. These mound features act as recharge zones for certain areas or sectors of this industrial area. Recharge may occur as a result of naturally permeable (sandy or silty) soils being exposed near or at the surface and collecting seepage from: direct precipitation, surface drainage, surface ponds or impoundments which provide a potentiometric head due to their perched position, or a combination of these possibilities.

The groundwater mounds or recharge areas are located generally northeast and east of the maleic pond, in and beyond the north and northeastern portion of the Denka plant, and in an area centered near the aeration (oxidation) ponds. A larger, more areal recharge influence is the higher altitude area to the extreme east near a residential area.

Discharge from the shallow silt occurs primarily through direct leakage or inflow of its strata into Sims Bayou and to a much lesser extent, through seepage into lower aquifer units.

Recharge to the regional aquifers at greater depth is generally by seepage from the local surface and is predominantly a result of recharge in the outcrop areas to the north and northeast of Houston. Discharge is upward through wells, into the Gulf of Mexico, and into other surface water bodies. The Chicot may leak downward into the Evangeline aquifer, but this leakage is usually slowed significantly by a common clay layer which separates the two aquifers.

Water quality from the Upper and Lower Chicot and from the Evangeline aquifer is very good and of fresh to slightly saline character except where ancient and recent saltwater encroachment nearer to the coastline has been incorporated within either major aquifer. Table 2.4 presents typical water quality in the Evangeline wells in the area of the site.

TABLE 2.4
WATER QUALITY OF GROUNDWATER WELLS LOCATED
WITHIN ONE MILE OF THE DENKA WASTE MANAGEMENT AREA

TDWR Well Number	Water- Bearing Unit	Date	Na ⁺ (mg/l)	HCO ₃ ⁻ (mg/l)	SO ₄ ²⁻ (mg/l)	Cl ⁻ (mg/l)	TDS (mg/l)	Hardness as CaCO ₃ (mg/l)	Specific Conductance (umhos)	pH (units)
65-22-301	E*	1949	222	442	0.6	96	577	18	984	7.9
	E	1968	-	460	-	106	-	23	1,010	8.2
-601	E	1944	225	470	3.0	83	574	17	1,110	7.7
	E	1958	-	442	-	60	-	12	826	8.7
-602	E	1970	-	416	-	77	-	20	872	7.9
-603	E	1969	234	444	0.0	120	602	19	1,040	8.2
-604	E	1969	234	476	0.0	74	581	13	996	8.6
-605	E	1969	193	432	6.0	52	492	24	814	8.2
	E	1972	-	368	-	50	-	30	752	8.2
-606	E	1970	237	484	0.0	93	586	12	991	8.5
	E	1971	-	464	-	92	-	17	1,000	8.0
-607	E	1970	142	307	11.0	47	372	20	627	8.5
	E	1971	-	300	-	50	-	32	639	7.7
-608	E	1970	236	484	0.0	92	583	14	972	8.4
	E	1971	-	470	-	59	-	12	901	8.0
-611	E	1960	132	268	22.0	41	349	15	565	8.6
-612	E	1961	130	283	12.0	41	348	19	580	8.4
-615	E	1938	160	365	0.0	43	583	12	-	-
	E	1949	-	318	-	46	-	20	627	-
-622	E	1973	190	384	7.0	80	491	26	875	7.9
65-23-127	E	1943	129	293	14.0	44	344	36	-	-
	E	1979	-	261	15.0	36	-	-	581	7.4

*E Evangeline aquifer

Sources: Gabrysch et al., February 1974 (TDWR - 178,III)
Ratzlaff et al., March 1984 (TDWR-285)

Water quality in the uppermost aquifer units generally is not suitable for domestic use, both historically and currently.

Well Inventory

A list of active or inactive groundwater wells within a one-mile radius of the Denka waste facility is presented in Table 2.5. This list includes ownership, designated uses of the produced water, details of construction, production rates, and whether water quality analyses are available. The locations of the listed wells are shown in Figure 2.3.

The Chicot and Evangeline aquifers have been utilized for domestic, stock, municipal, industrial, and other assorted uses in the Houston district. The reported groundwater yields have been a maximum of 2,000 to 3,000 gallons per minute in some wells within either aquifer.

SURFACE HYDROLOGY

This section of the application addresses the meteorological and surface hydrological conditions at the site. The discussion includes rainfall data and hydraulically connected surface water features, as well as surface water uses and quality.

Based on 30 years of record, the long-term average annual precipitation at the facility is approximately 49 inches (Larkin, 1983). Table 2.6 provides a breakdown of the long-term average monthly precipitation record. For the same period of record, the average annual gross lake surface evaporation rate was 51.5 inches.

The nearest significant surface water feature to the hazardous waste management area is Sims Bayou, which is also hydraulically connected to the shallow water-bearing zone and downgradient of the plant. The storm water pond, maleic pond, and Imhoff pond are located approximately 200 feet, 300 feet, and 450 feet, respectively, northeast of Sims Bayou. Flow distances to the Bayou for each of the ponds were not determined precisely since wastewater in these ponds receives treatment in the oxidation ponds (NPDES system) prior to discharging to the bayou. The approximate distance for this flow route is one-half mile.

Shallow groundwater at the site is believed to discharge to the bayou. Sims Bayou eventually enters the Houston Ship Channel and is part of

TABLE 2.5
GROUNDWATER WELLS LOCATED WITHIN A ONE-MILE RADIUS
OF THE DENKA CHEMICAL WASTE FACILITY

DWR Number	Owner	Date Com- pleted	Depth of well (ft.)	Casing		Water Bearing unit	of land surface (ft.)	Water Level		Use of Water	Remarks
				Diam- eter (in.)	Depth (ft.)			Below land surface datum (ft)	Date of Measure- ment		
*65-22-301	City of Houston East End Well 5	1949	2,580	24 12	595 2,580	E	15	313.8	1969	N	407 ft. of screen between 1,470 and 2,560 ft. Measured yield 1,945 gpm with 54 ft. drawdown when drilled. Well destroyed.
65-22-330	Best Fertil- izers	1963	684	7 5	587 684	CL	25	--	--	Ind	60 ft. of screen between 613 and 684 ft.
*65-22-601	City of Houston East End Well 2	1943	2,060	24 12	598 2,060	E	33	256	1956	N	269 ft. of screen between 1,222 and 2,050 ft. Reported yield 1,000 gpm with 34 ft. drawdown when drilled. Well destroyed.
*65-22-602	City of Houston East End Well 3	1948	2,365	24 12	580 2,365	E	33	336.7	1979	P	365 ft. of screen between 1,195 and 2,345 ft. Measured yield 1,865 gpm with 38 ft. drawdown Dec. 1950.
*65-22-603	City of Houston East End Well 4	1948	2,530	24 12	600 2,530	E	30	336.3	1979	P	405 ft. of screen between 1,000 and 2,510 ft. Measured yield 2,560 gpm with 49 ft. drawdown when drilled.
*65-22-604	City of Houston East End Well 6	1949	2,095	24 12	600 2,095	E	34	326.9	1979	N	411 ft. of screen between 945 and 2,069 ft. Measured yield 2,577 gpm with 54 ft. drawdown when drilled.
*65-22-605	City of Houston East End Well 7	1955	1,770	24 12	610 1,770	E	30	321.0	1979	P	380 ft. of screen between 785 and 1,755 ft. Measured yield 2,513 gpm with 60 ft. drawdown when drilled.
*65-22-606	Petro-Tex Corp. Well 1	1942	1,710	20 10	1,215 1,710	E	34	359	1970	Ind	213 ft. of slotted casing between 1,375 and 1,694 ft. Reported yield 916 gpm with 54 ft. drawdown when drilled.
*65-22-607	Petro-Tex Corp. Well 2	1942	1,222	20 10	840 1,222	E	34	302.8	1963	Ind.	221 ft. of slotted casing between 856 and 1,205 ft.
*65-22-608	Petro-Tex Corp. Well 3	1953	1,712	20 12	1,200 1,712	E	34	360	1970	Ind	242 ft. of screen between 1,220 and 1,692 ft. Reported yield 1,600 gpm with 35 ft. drawdown when drilled. Test hole drilled to 1,796 ft.
65-22-609	Goodyear Tire and Rubber Co. Well 3	1956	1,205	14 8	710 1,205	E	35	289	1956	Ind	110 ft. of screen between 848 and 1,200 ft. Reported yield 610 gpm with 46 ft. drawdown when drilled.
65-22-610	Goodyear Tire and Rubber Co.	1958	1,190	14 6	710 1,190	E	35	298	1958	Ind	110 ft. of screen between 850 and 1,185 ft. Reported yield 560 gpm with 46 ft. drawdown when drilled.
*65-22-611	U.S.S Chemicals Well 1	1960	1,212	16 10	800 1,212	E	32	307	1960	Ind	161 ft. of screen between 812 and 1,193 ft. Reported yield 1,065 gpm with 50 ft. drawdown when drilled.
*65-22-612	U.S.S. Chemicals Well 2	1960	1,215	16 10	805 1,215	E	32	--	--	N	156 ft. of screen between 809 and 1,195 ft. Reported yield 1,100 gpm with 45 ft. drawdown Feb. 1962.
65-22-613	Goodyear Tire and Rubber Co. Well 1	1943	1,055	8	1,055	E,CL	33	205.6	1949	N	146 ft. of screen between 600 and 1,055 ft.
65-22-614	Goodyear Tire and Rubber Co. Well 2	1949	1,039	8 7	-- 1,039	E	33	222	1949	N	Screen from 959 to 1,039 ft.

*65-22-615	City of Houston East End Well 1	1930	1,551	24 12	350 1,551	E	34	270.5	1965	N	225 ft. of screen between 1,027 and 1,648 ft. Reported yield 2,146 gpm with 55 ft. drawdown when drilled.
65-22-619	U.S.S. Chemicals Well 3	1965	1,213	16 10	652 1,213	E	32	345	1965	N	185 ft. of screen between 662 and 1,207 ft. Reported yield 1,001 gpm with 39 ft. drawdown when drilled.
65-22-620	U.S.S. Chemicals Well 4	1965	1,203	16 10	630 1,203	E	32	355	1965	N	196 ft. of screen between 636 and 1,154 ft. Reported yield 1,001 gpm with 39 ft. drawdown when drilled.
65-22-621	Occidental Chemical Company	1970	674	4 2 1/2	648 674	CL	25	343	1970	Ind	Screen from 652 to 672 ft.
*65-22-622	U.S. Geological Survey	1973	995	4 1 1/2	985 995	E	34	328.4	1979	N	Screen from 975 to 995 feet Borehole extensometer.
65-22-623	U.S. Geological Survey	1974	64	2	64	CU	34	14.3	1979	N	Screen from 44 to 64 feet. Observation well.
65-23-109	Manchester Terminal Well 2	1950	782	18 12 6	38 589 782	E	20	218.6	1950	Ind	65 ft. of screen between 602 and 750 ft.
*65-23-127	Atlantic Richfield Co. Well 9	1940	1,192	20 10	783 1,192	E	33	124	1940	Ind	178 ft. of screen between 899 and 1,186 ft. Reported yield 1,785 gpm with 84 ft. drawdown when drilled. Formerly Sinclair Refining Co.
65-23-134	Manchester Terminal	1932	658	10 8	-- 658	CL	20	153	1944	N	Screen from 615 to 658 ft. Reported yield 200 gpm with 26 ft. drawdown when drilled.
65-23-404	B. F. Harris	1941	645	6 4	318 645	CL	33	111	1941	N	Screen from 603 to 645 ft. Formerly supplied Allendale Subdivision.
65-23-405	Forest Oaks Water Works	1937	923	6	923	E	31	78	1937	N	Screen from 893 to 923 ft. Reported yield 220 gpm when drilled. Well destroyed.
OTHER SMALLER WELLS											
65-22-3A	Gulf Coast Cement Company Well 1	1962	806	12 3/4	600	E,CL	--	264	1962	Ind	75 ft. of screen between 605 and 794 ft. Reported yield 354 gpm.
65-22-3D	Lone Star Industries	1974	1,104	--	990	E	--	402	1974	Ind	47 ft. of screen between 990 and 1,102 ft. Reported yield 510 gpm.
65-22-6D	Tradewind Mobile Homes	1980	241	2	84	CU	--	13	1980	D	Screen from 84 to 94 ft. Reported yield 30 gpm
65-22-6F	Jerry Sanford	1982	317	4	303	CL	--	190	1982	D	Screen from 307 to 317 ft. Reported yield 10 gpm.

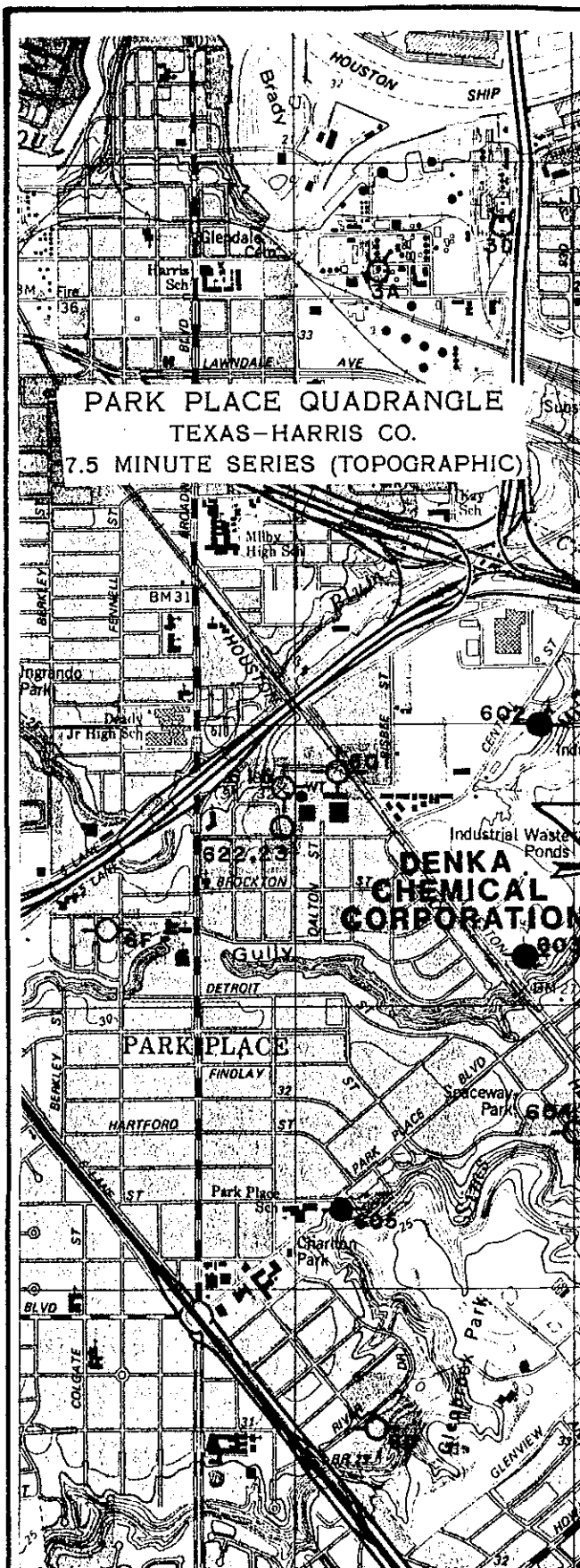
Notes: All wells are drilled unless otherwise noted in remarks column.

Water level : Reported water levels given in feet; measured water levels given in feet and tenths.
Use of water : D, domestic; Ind, industrial; Irr, irrigation; N, none; P, Public Supply; S, livestock.
Water bearing unit : C, Chicot aquifer; CU, Upper unit of Chicot aquifer; CL, Lower unit of Chicot aquifer;
E, Evangeline aquifer; J, Jasper aquifer.








* Indicates water quality analysis on Table 2-4, this report.

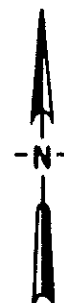
Sources: Gabrysch et al., February 1974 (TDWR-178, II)
Naftel et al., March 1976 (TDWR-203)
Ratzlaff et al., March 1984 (TDWR-285)
TDWR File Review, Plotted Drillers Logs (February 1985)

FIGURE 2-3
GROUNDWATER WELLS
LOCATED WITHIN A
ONE-MILE RADIUS OF THE
DENKA FACILITY



KEY:

-  INDUSTRIAL WELL
-  PUBLIC SUPPLY WELL
-  OBSERVATION WELL
-  DOMESTIC WELL
-  { ABANDONED OR UNUSED
WELLS
-  6F PLOTTED DRILLERS WELL
-  623 TDWR LOCATED WELL



QUADRANGLE LOCATION

TABLE 2.6
LONG TERM AVERAGE PRECIPITATION BY MONTH*
DENKA CHEMICAL CORPORATION

Month	Inches
January	3.25
February	3.25
March	2.70
April	4.00
May	4.25
June	5.00
July	4.50
August	4.50
September	5.80
October	3.60
November	4.00
December	<u>3.75</u>
Total	48.60

* Source: Climatic Atlas of Texas, TDWR LP-192 (1983)
Period of Record: 1951-1980

Segment 1006 of the San Jacinto River Basin, classified for navigation and industrial water supply only. The water in this segment is not considered suitable for recreation, preservation of wildlife, or domestic water supply. Applicable TDWR water quality standards are shown in Table 2.7. Estimates of Sims Bayou streamflow are provided in the next section of this application.

Stream samples were taken from Sims Bayou in late January 1985, at points both upstream and downstream of Denka Chemical Corporation. The samples were analyzed for benzene, toluene, 1,1,2,2-tetrachloroethane, and trichloroethylene, as well as for the conventional gross indicator parameters, TOC, TOX, and pH. Results of the chemical analyses are presented in Table 2.8. It should be noted that all of the specific organics were determined to be below the method detection limit of 10 ug/l.

ESTIMATE OF PROJECTED AND WORST-CASE IMPACTS

The principal potential impacts of the contaminants identified in shallow groundwater at Denka Chemical Corporation are on Sims Bayou. As discussed in the Groundwater Quality Assessment Plan Report of First Determination (Geo Associates, September 1984) the shallow groundwater is believed to be connected hydraulically to this stream, and no contaminants were identified in the deeper sands (El-45 ft). Furthermore, evidence was presented which suggests that the hydraulic connection between the uppermost aquifer and deeper sands is little to none.

The shallow groundwater was found to be contaminated with benzene and toluene at ppb levels. This section provides an estimate of groundwater flow based on field measurements. The contaminant concentration data collected during the assessment program are then used to project loadings to the river. Given streamflow, the resulting concentrations of these contaminants in the bayou also are calculated to provide an estimate of their potential environmental effects.

In addition, this section presents an estimate of worst-case impact to the receiving water based on lower streamflow rates as represented by the 7-day, one-in-two-year low flow data for Sims Bayou. The worst-case scenario also utilizes the observed contaminant concentrations but conservatively assumes no additional porewater dilution from the groundwater

TABLE 2.7
SURFACE WATER QUALITY STANDARDS FOR
SEGMENT 1006 OF THE SAN JACINTO RIVER BASIN*

Parameter	Standard
Chloride, mg/l	**
Sulfate, mg/l	**
TDS, mg/l	**
Dissolved Oxygen, mg/l	2.0, minimum
pH, units	6.5-9.0
Fecal Coliform, No. per 100 mls.	2,000, maximum
Temperature, °F	95, maximum

* Source: Texas Surface Water Quality Standards, TDWR (August, 1984)

** Indicates standards not specified for parameter

TABLE 2.8

ANALYTICAL RESULTS OF HAZARDOUS CONSTITUENTS
IN SIMS BAYOU NEAR DENKA CHEMICAL CORPORATION*

Chemical Parameter	Concentration, ug/l	
	Upstream	Downstream
Benzene, ug/l	<10	<10
Toluene, ug/l	<10	<10
1,1,2,2-Tetrachloroethane, ug/l	<10	<10
Trichloroethene, ug/l	<10	<10
Total Organic Carbon, mg/l	8.0	7.0
Total Organic Halogens, mg/l	0.170	0.270
pH, units	7.7	7.6

*Date of Sample Collection: January 30, 1985

monitoring well to the point of introduction into the receiving stream. It should be recognized that benzene has not been utilized in the maleic process since 1981. Thus, the 1983 observed monitoring well concentration of benzene should be reasonably applicable to the worst-case determination for that toxicant. The following discussion presents both the projected and worst-case analyses.

Groundwater flow in the uppermost aquifer can be estimated from field measurements of hydraulic conductivity (K) and reasonable assumptions about hydraulic gradient (i) and cross-sectional area (A). Piezometer slug tests were run on wells 2, 3, and 5a to evaluate hydraulic conductivity (coefficients of permeability). These in situ tests resulted in calculated values of hydraulic conductivity of 2.2×10^{-3} , 4.7×10^{-3} , and 1.1×10^{-3} cm/sec for wells 2, 3, and 5a, respectively. The greatest of these three measurements is selected here for conservatism.

Based on observed static water levels, hydraulic gradients within the shallow silt between up- and downgradient wells were calculated in the range of 0.0011 to 0.0095, as reported in the Assessment Report of First Determination (Geo Associates, September 1984). However, greater gradients are believed to exist between the point of compliance and Sims Bayou based on topography. A conservative estimate of hydraulic gradient was calculated by comparing the average static water level at downgradient well 2 with the free surface elevation of Sims Bayou:

$$i = \frac{\text{Change in water surface elevation (well 2 versus stream)}}{\text{Horizontal distance}}$$
$$= (9 \text{ ft} - 0 \text{ ft}) / 180 \text{ ft} = 0.05$$

Reasonable confidence is assigned to this value as a conservative estimate since Geo Associates assumed a gradient of 0.025 between well 2 and Sims Bayou in their assessment report (September 1984).

The cross-sectional area through which contaminants possibly could pass also was estimated. Figure 2.2 presented the stratigraphic profile for subsoils at the site. Using this figure and the known distance of

approximately 1,000 feet between downgradient wells 1 and 5a, a conservative cross-sectional area of 10,000 square feet is assumed. The groundwater flow for the uppermost unit can then be calculated:

$$\begin{aligned}
 Q &= K i A \\
 &= (4.7 \times 10^{-3} \text{ cm/s})(0.05)(10,000 \text{ ft}^2)(86,400 \text{ s/day}) \\
 &\quad (\text{ft}/30.48 \text{ cm})(7.481 \text{ gal/ft}^3) \\
 &= 49,834 \text{ gpd} = 0.05 \text{ mgd}
 \end{aligned}$$

At this estimated flow rate, the projected benzene loading on the bayou can be calculated based on the observed monitoring well concentration:

$$\begin{aligned}
 \text{Projected Benzene Loading} &= (0.05 \text{ mgd})(0.024 \text{ mg/l})(8.34) \\
 &= 0.010 \text{ lb/day}
 \end{aligned}$$

The same calculation for toluene resulted in a projected loading of 0.016 pounds per day.

The resulting stream concentration of these contaminants can be projected by a simple mass balance if stream flow rates are known. Unfortunately, there are no gauging stations for streamflow measurements on Sims Bayou in the vicinity of the plant. A USGS surface water station (number 0807550) is located several stream miles upstream of the site; however, this station includes only flow prior to the confluence of Berry Bayou which is also upstream of the Denka location. The 31-year mean discharge at this upstream gauging station is 83.8 cubic feet per second (Water Resources Data, Texas, Water Year 1983). The median streamflow (flow rate measured or exceeded 50 percent of the time) for 1983 was 53 cubic feet per second at this upstream station. To account for the influx of Berry Bayou and stream recharge from other sources between the gauging station and the plant location, a normal flow rate of 74 cubic feet per second (48.06 mgd) was calculated for Sims bayou in the vicinity of Denka. This streamflow estimate was determined by applying a ratio derived from available 7-day, one-in-two-year low flow data to the median discharge at the upstream

gauging station. The low-flow data were developed by the TDWR and published in the March 1983 draft report Waste Load Evaluation for the Houston Ship Channel System in the San Jacinto River Basin. From this report, incremental streamflow values corresponding to the 7-day, two-year low flows in the appropriate reaches of Sims Bayou and its tributary were obtained and summed to arrive at an approximate 7-day, two-year low flow total in the vicinity of Denka. The ratio of this calculated total to the low flow value at the upstream gauging station was then applied to the median discharge at the upstream gauging station to determine the normal streamflow for Sims Bayou in the vicinity of the plant.

Using this estimate of streamflow and the projected contaminant loading from groundwater, the resulting incremental increase in surface water concentration of contaminants can be calculated by a mass balance:

$$Q_1 C_1 + Q_W C_W = Q_2 C_2$$

where:

- Q_1 = initial stream flow, 48.06 mgd;
- Q_W = contaminated groundwater influx, 0.05 mgd;
- Q_2 = streamflow after mixing = $Q_1 + Q_W$;
- C_1 = initial contaminant concentration in stream;
- C_W = groundwater concentration impacting stream; and
- C_2 = final concentration in stream.

Rearranging,

$$C_2 = (Q_1 C_1 + Q_W C_W) / (Q_1 + Q_W)$$

If $Q_1 \gg Q_W$, the incremental increase in concentration over C_1 is represented by:

$$(Q_W C_W) / (Q_1 + Q_W)$$

This expression is also equal to the final concentration C_2 if C_1 equals zero.

For benzene, the incremental increase in surface water concentration is:

$$\begin{aligned}\text{Projected Benzene Concentration over Initial} &= \\ (0.05 \text{ mgd})(24 \text{ ug/l}) / (48.11 \text{ mgd}) & \\ &= 0.025 \text{ ug/l}\end{aligned}$$

In the case of toluene, the projected concentration increase due to groundwater impact is 0.041 ug/l. These calculations imply that very insignificant impacts can be expected if based on reasonable flows and the observed concentrations of toxicants in the groundwater.

Assumptions also were made to enable an estimate of the impact to stream quality for a theoretical worst case. For this case, it is assumed that Sims Bayou streamflow is much lower, represented by the calculated 7-day, one-in-two-year low flow value derived from the aforementioned TDWR report, and that no additional porewater dilution of contaminants occurs from the GWM well location to the point of stream introduction. The 7-day, one-in-two-year low flow estimate for Sims Bayou near the plant site is 7.10 cubic feet per second (4.59 mgd). With these assumptions and utilizing the observed contaminant concentrations and the previously estimated groundwater flow rate, the worst-case stream concentration for benzene is calculated as follows:

$$\begin{aligned}\text{Worst-case } C_2 \text{ for Benzene} &= \\ [(0.05 \text{ mgd})(24 \text{ ug/l}) / (4.59 + 0.05) \text{ mgd}] & \\ &= 0.92 \text{ ug/l}\end{aligned}$$

The comparable calculation for toluene results in a worst-case final stream concentration (or increase) of 0.42 ug/l.

In all cases, projected and worst-case for benzene and toluene, the impact to Sims Bayou appears to be less than a 1 ug/l increase over existing stream quality conditions (in terms of individual toxicant concentrations). These analyses were based on reasonable assumptions. More accurate estimates could be attained with better definition of streamflow and other parameters.

WASTE EXPOSURE HAZARDS

This section provides documentation of known environmental hazards and health risks associated with the contaminants for which alternate concentration limits are sought. For each toxicant (benzene, toluene), three forms of potential hazard are discussed: (1) human health risks, acute, chronic, and otherwise; (2) environmental toxic effects, including reported effects on flora and fauna; and (3) chemical persistence and probable fate mechanisms.

Benzene

Most of the human health effects of benzene have been reported with respect to vapor inhalation. Symptoms of acute exposure from inhalation or ingestion have included irritation of mucous membrane, restlessness, convulsions, and respiratory failure (Merck, 1983). As a measure of acute toxicity, Kimura et al. (1971) have demonstrated an LD50 (rats, oral) of 3,339 mg/kg, which is considered moderately toxic (Sax, 1979). Reported chronic effects have included bone marrow depression, aplasia, and, rarely, leukemia; however, exposure concentrations were not assigned to these chronic symptoms (Merck, 1983). Benzene has been listed as a carcinogen by the EPA (U.S. EPA, 1981). Because of this factor, water quality criteria for benzene are expressed not as a single value but as a set of values corresponding to estimated population increases in cancer risk. For direct human consumption of water and aquatic organisms, the criteria are 6.6 ug/l, 0.66 ug/l, and 0.066 ug/l, corresponding to estimated lifetime incremental risk increases of 10^{-5} , 10^{-6} , and 10^{-7} . If these estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 400 ug/l, 40 ug/l, and 4.0 ug/l, respectively. Benzene has not demonstrated the tendencies of teratogenicity (Murray et al., 1979) or bioaccumulation (Weiss, 1980).

Benzene has been the subject of numerous studies to determine the impact of concentrations to flora and fauna. The lowest reported concentration to produce acute toxicity to freshwater aquatic life is 5.3 mg/l (U.S. EPA, Federal Register, 1980). Weiss (1980) has reported lethal toxicity to minnows when exposed to 5-7 mg/l in distilled water for six hours and a median threshold limit of 20 ppm for sunfish exposed for 24 hours. A similar value was given for the 96-hour LC50 for certain crustaceans (Benville and Korn, cited by Verschueren, 1983). The threshold concentration for benzene toxicity toward green algae has been reported to be >1,400 mg/l, which approaches the aqueous solubility of the compound (Bringmann and Kuhn, 1980). The same authors reported a toxicity threshold of 92 mg/l for bacteria in the cell multiplication inhibition test. No data were found in the literature regarding benzene toxicity toward higher plants or crops.

Because of its chemical structure (aromatic symmetry and electron delocalization), benzene is generally regarded as a persistent toxicant in the water phase; however, there is evidence of gradual biodegradation at low concentrations by aquatic microorganisms (Walker and Colwell, 1975). The rate of biodegradation appears to be enhanced when other hydrocarbons are present also. The primary pathway and fate of benzene in surface water is volatilization followed by atmospheric oxidation (U.S. EPA, 1979). Mackay and Wolkoff (1973) reported water phase half-lives for benzene on the order of five hours.

All of the above data suggest that benzene is a moderate toxicant to aquatic life with observable effects at concentrations above 5 mg/l. However, because benzene is a suspected carcinogen, surface waters such as Sims Bayou which conceivably could serve as a reservoir for consumable organisms, should be protected at least to the 40 ug/l level. It is likely that most of any benzene which reaches Sims Bayou eventually would be biodegraded or volatilized to the atmosphere and rapidly oxidized.

Toluene

Toluene generally is regarded as a low-level hazard in aquatic settings. Human health effects occur when the chemical is ingested or inhaled

directly. Acute effects of inhalation include membrane irritation, headache, and respiratory arrest (Weiss, 1980). No chronic effects other than mild macrocytic anemia (Merck, 1983) were found. As an indication of toxicity, Smyth et al. (1969) reported an LD50 (rats, oral) of 7,530 mg/kg, which classifies the compound as a moderate to low toxicant (Sox, 1979). Toluene is not regarded as a carcinogen, teratogen, or mutagen, and does not bioaccumulate (Weiss, 1980; U.S. EPA, 1979).

Several studies which reported toxic effects to flora and fauna were identified. The EPA indicated that the lowest reported acute toxicity to freshwater aquatic life was 17.5 mg/l (U.S. EPA, Federal Register, 1980); however, Benville and Korn reported a 96-hour LC50 of 7.3 mg/l for striped bass (cited by Verschueren, 1983). Other reported toxicities include a 96-hour LC50 of 4.3 mg/l toward shrimp (Benville and Korn) and a median threshold limit of 1,180 mg/l toward sunfish (Weiss, 1980). The only data found for toluene toxicity toward plants was for lower plants; i.e., algae. In the cell multiplication inhibition test, the lowest toxicity threshold reported was 29 mg/l (Bringmann and Kuhn, 1980). No studies were found which evaluated toluene toxicity toward higher plants or crops.

The principal mechanism for removal of toluene from the aquatic environment is volatilization (U.S. EPA, 1979). The half-life of toluene in the water phase has been estimated to be 5.18 hours (Mackay and Leinonen, 1975). Once in the atmosphere, destruction by photooxidation is likely to take place (Laity et al., 1973). Biodegradation data for toluene is not abundant; however, Jamison et al. (1976) reported 100 percent biodegradation of 2.2 ug/l by natural flora in groundwater when in the presence of other components of gasoline.

All of the available data for toluene suggest that it poses a low health and environmental hazard when present in low aquatic concentrations. The lowest reported concentration of toxic effect in a freshwater environment is 7.3 mg/l. The EPA has established an ambient water criterion of 424 mg/l for protection of human health in surface waters which does not serve as a drinking water source but does contain consumable organisms (U.S. EPA, Federal Register, 1980). Biodegradation in groundwater and surface waters and volatilization in surface waters appear to be the probable fate mechanisms of toluene.

BASIS FOR ALTERNATE CONCENTRATIONS

This section presents the technical justification for the alternate concentration limits sought by Denka Chemical Corporation in groundwater at the point of compliance with respect to benzene and toluene.

While other Appendix VIII constituents also have been identified in the downgradient wells, special exemptions or alternate determinations of concentration limits are proposed for all except benzene and toluene, as discussed in the proposed groundwater protection standard section of Part 1 of this application. In the case of methylene chloride and bis(2-ethylhexyl)phthalate, the requested exemption is based upon the fact that neither compound is used or generated at the Denka plant and both are common systematic contaminants which frequently appear in analytical results for groundwater monitoring. For 1,1,2,2-tetrachloroethane and trichloroethylene, Denka proposes to establish the concentration limits of these species through sampling at upgradient wells each time groundwater is sampled at the compliance point, since the suspected source is off-site. This determination method is provided for in TAC Section 335.465(3)(A).

The following discussion centers around alternate concentration limits for benzene and toluene. The primary approach to establishing the alternate concentrations is the perceived impact to the adjacent bayou; however, considerations of the potential effect on deeper groundwater also are addressed.

Benzene

As noted in the previous section on waste exposure hazards, benzene does not exhibit an acute toxic effect on aquatic life until present in concentrations above 5 mg/l. However, because benzene is a suspected carcinogen, the EPA has promulgated water quality criteria to protect human health on the basis of relative population increases in cancer risk. For the case of surface waters which may be the source of consumable aquatic organisms but do not serve as intakes for drinking water, as is the case of Sims Bayou, the human health protection criteria are 400 ug/l, 40 ug/l, and

4 ug/l, corresponding to estimated lifetime cancer risk increments of 10^{-5} , 10^{-6} , and 10^{-7} , respectively (U.S. EPA, Federal Register, 1980). Thus, the most stringent surface water quality criteria found for benzene which applies to the present site situation is 4.0 ug/l. For the purpose of this development, a targeted surface water criterion of 4.0 ug/l is used.

By employing the mass balance tool presented in a previous section, the maximum allowable groundwater concentration can be calculated. The simple pictorial and mathematical model is presented in Figure 2.4. It is conservatively assumed that no additional porewater dilution of contaminant occurs while enroute from the downgradient well to the point of introduction into the stream. By combining the target surface water criterion and the same groundwater and normal streamflow rates as estimated in the impact analysis, the calculation indicates that a GWM well contamination level of 3,845 ug/l would need to be detected before the stream concentration of benzene reached 4.0 ug/l. This calculated level is over two orders of magnitude greater than that which has been observed for benzene to date in the downgradient well.

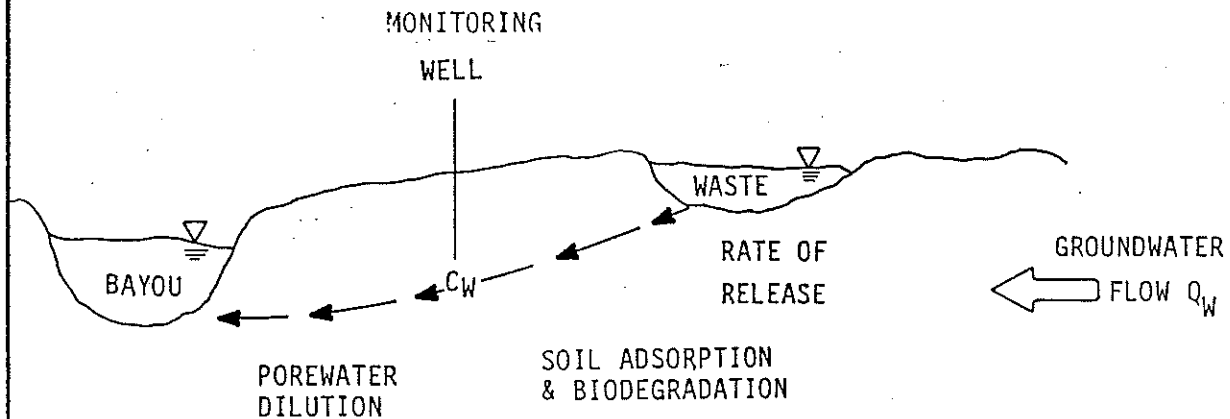
Based on the foregoing analysis, the alternate concentration proposed by Denka for benzene is 500 ug/l. This concentration limit would provide reasonable assurance (7.5-fold factor of safety) that the receiving water would be protected against measurable risk to human health or the environment. This factor of safety is invoked over and above the conservatism already built into the model by assumptions and the value used for the water quality criterion. It should be emphasized that acute toxic effects of benzene to aquatic life have been demonstrated only at levels some three orders of magnitude higher than the water quality criterion chosen for use in these calculations. The chronic effect concentration used here is generally applied only to waters suitable for fishing and indirect human consumption. Sims Bayou is not classified for consumptive or recreational use.

Toluene

The most stringent water quality criteria found for toluene is that determined by EPA for the protection of human health from toxic properties of the compound ingested through water and contaminated organisms. That ambient water criterion was established at 14.3 mg/l (U.S. EPA, Federal

FIGURE 2-4

REPRESENTATION OF MODEL USED TO GUIDE SELECTION OF ALTERNATE CONCENTRATIONS



TERMS:

Q_1 = INITIAL STREAM FLOW
 Q_W = CONTAMINATED GROUNDWATER FLOW
 Q_2 = STREAM FLOW AFTER MIXING

C_1 = INITIAL STREAM CONCENTRATION
 C_W = GROUNDWATER CONCENTRATION
 C_2 = TARGETED WATER QUALITY CRITERIA

MASS BALANCE EQUATION:

$$Q_1 C_1 + Q_W C_W = Q_2 C_2$$

$$C_W = \frac{Q_2 C_2 - Q_1 C_1}{Q_W}$$

Register, 1980). For the case of toluene ingested through contaminated aquatic organisms above, the ambient water criterion is 424 mg/l.

By using a targeted surface water criteria of 2.0 mg/l (well below the EPA-established levels), the mass balance model calculations indicate that a GWM well contamination level of 1,924 mg/l would need to be detected before the targeted stream quality concentration was reached. Again, this calculation conservatively assumes that no additional porewater dilution would occur between the well and the stream. This calculated level is over 10^4 times that which has been observed for toluene in the downgradient well.

In light of these observations, the alternate concentration limit proposed by Denka for toluene is 2.0 mg/l. This limit would assure a 1,000-fold factor of safety on the already-conservative targeted stream quality standard of 2.0 mg/l when applying the mass balance equation to assess stream impact from shallow groundwater contamination.

Potential Effect on Deeper Groundwater

During the contamination assessment program, hydrographs of all the existing wells were plotted. The hydrographs suggested that while there is good hydraulic connection among wells in the shallow sands, the connection between the shallower and deeper sands in the vicinity of the surface impoundments is poor (Geo Associates, September 1984).

The soil borings indicated the presence of a relatively thick confining clay zone with a vertical permeability of less than 10^{-8} cm/sec between the uppermost and deeper water-bearing units. It was also noted that some communication between sands may exist south of tanks 412 and 413 in the vicinity of well 5a. Because of the apparent isolation of the uppermost sands from deeper strata, it is believed that the alternate concentrations sought will not allow the deeper, more regional groundwater to be impacted significantly. Assurance of this contention, however, will be provided by periodic sampling of the deeper wells 21 and 22, as outlined previously in the groundwater compliance plan.

CORRECTIVE ACTION FEASIBILITY PLAN

Based on the alternate concentrations sought and other exemptions or variances proposed in this application, Denka groundwater quality has not exceeded the proposed groundwater protection standard. Thus, as provided for in Section 335.464(8)(E)(ii)(II) of the TAC, an engineering feasibility plan for a corrective action program has not been prepared as part of this compliance plan application. In effect, the correction action program at this time remains in the form of "no corrective action is needed."

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APPENDIX

ANALYTICAL DATA, NUS CORPORATION
(December 1983)



Laboratory Services Division
900 Gemini Avenue
Houston, TX 77058

REMIT TO:
900 Gemini Avenue
Houston, TX 77058

713-488-1810

LAB ANALYSIS REPORT

CLIENT NAME: GEO-ASSOCIATES
ADDRESS: 10701 CORPORATE DRIVE, SUIT 282
STAFFORD, TX 77477

NUS PROJECT NO: 000000
NUS CLIENT NO: 721501

REPORT DATE: 12/28/83

ATTENTION: WAYNE S. POLLARD

DATE RECEIVED: 12/06/83

SAMPLE IDENTIFICATION	NUS SAMPLE NO	RESULTS	UNITS
WELL 1 (DEWKA)	12/05	23120214	
0110 VOLATILES-PP IN WATER			
OV01 Acrolein		< 100	ug/l
OV02 Acrylonitrile		< 100	ug/l
OV03 Benzene		< 10	ug/l
OV05 Bromoform		< 10	ug/l
OV06 Carbon Tetrachloride		< 10	ug/l
OV07 Chlorobenzene		< 10	ug/l
OV08 Chlorodibromomethane		< 10	ug/l
OV09 Chloroethane		< 10	ug/l
OV10 2-Chloroethylvinyl Ether		< 10	ug/l
OV11 Chloroform		< 10	ug/l
OV12 Dichlorobromomethane		< 10	ug/l
OV14 1,1-Dichloroethane		< 10	ug/l
OV15 1,2-Dichloroethane		< 10	ug/l
OV16 1,1-Dichloroethylene		< 10	ug/l
OV17 1,2-Dichloropropane		< 10	ug/l
OV18 1,3-Dichloropropylene		< 10	ug/l
OV19 Ethylbenzene		< 10	ug/l
OV20 Methyl Bromide		< 10	ug/l
OV21 Methyl Chloride		< 10	ug/l
OV22 Methylene Chloride		< 10	ug/l
OV23 1,1,2,2-Tetrachloroethane		< 10	ug/l
OV24 Tetrachloroethylene(Perchloro)		< 10	ug/l
OV25 Toluene		< 10	ug/l
OV26 1,2-Trans-Dichloroethylene		< 10	ug/l
OV27 1,1,1-Trichloroethane		< 10	ug/l
OV28 1,1,2-Trichloroethane		< 10	ug/l
OV29 Trichloroethylene		< 10	ug/l
OV31 Vinyl chloride		< 10	ug/l
0120 ACIDS - PP IN WATER			
OA01 2-Chlorophenol		< 10	ug/l
OA02 2,4-Dichlorophenol		< 10	ug/l



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NUS PROJECT NO: 000000
NUS CLIENT NO: 721501

REPORT DATE: 12/28/83

ATTENTION: WAYNE S. POLLARD

DATE RECEIVED: 12/06/83

SAMPLE IDENTIFICATION	NUS SAMPLE NO	RESULTS	UNITS
0A03 2,4-Dimethylphenol		< 10	ug/l
0A04 4,6-Dinitro-o-cresol		< 10	ug/l
0A05 2,4-Dinitrophenol		< 10	ug/l
0A06 2-Nitrophenol		< 10	ug/l
0A07 4-Nitrophenol		< 10	ug/l
0A08 p-Chloro-m-cresol		< 10	ug/l
0A09 Pentachlorophenol		< 10	ug/l
0A10 Phenol		< 10	ug/l
0A11 2,4,6-Trichlorophenol		< 10	ug/l
0E30 Acid Extraction-Water			
0130 BASE NEUTRALS - PP IN WATER			
0801 Acenaphthene		< 10	ug/l
0802 Acenaphthylene		< 10	ug/l
0803 Anthracene		< 10	ug/l
0804 Benzidine		< 10	ug/l
0805 Benzo(a)Anthracene		< 10	ug/l
0806 Benzo(a)Pyrene		< 10	ug/l
0807 3,4-Benzofluoranthene		< 10	ug/l
0808 Benzo(ghi)Perylene		< 10	ug/l
0809 Benzo(k)Fluoranthene		< 10	ug/l
0810 Bis(2-Chloroethoxy)Methane		< 10	ug/l
0811 Bis(2-Chloroethyl)Ether		< 10	ug/l
0812 Bis(2-Chloroisopropyl)Ether		< 10	ug/l
0813 Bis(2-Ethylhexyl)Phthalate		< 10	ug/l
0814 4-Bromophenyl Phenyl Ether		< 10	ug/l
0815 Butyl Benzyl Phthalate		< 10	ug/l
0816 2-Chloronaphthalene		< 10	ug/l
0817 4-Chlorophenyl Phenyl Ether		< 10	ug/l
0818 Chrysene		< 10	ug/l
0819 Dibenzo(a,h)Anthracene		< 10	ug/l
0820 1,2-Dichlorobenzene		< 10	ug/l
0821 1,3-Dichlorobenzene		< 10	ug/l
0822 1,4-Dichlorobenzene		< 10	ug/l
0823 3,3'-Dichlorobenzidine		< 10	ug/l



Laboratory Services Division
900 Gemini Avenue
Houston, TX 77058

REMIT TO:
900 Gemini Avenue
Houston, TX 77058

713-488-1810

LAB ANALYSIS REPORT

CLIENT NAME: GEO-ASSOCIATES
ADDRESS: 10701 CORPORATE DRIVE, SUIT 282
STAFFORD, TX 77477

NUS PROJECT NO: 000000
NUS CLIENT NO: 721501

REPORT DATE: 12/28/83

ATTENTION: WAYNE S. POLLARD

DATE RECEIVED: 12/06/83

SAMPLE IDENTIFICATION

SAMPLE IDENTIFICATION	NUS SAMPLE NO	RESULTS	UNITS
0824 Diethyl Phthalate		< 10	ug/l
0825 Dimethyl Phthalate		< 10	ug/l
0826 Di-N-Butyl Phthalate		< 10	ug/l
0827 2,4-Dinitrotoluene		< 10	ug/l
0828 2,6-Dinitrotoluene		< 10	ug/l
0829 Di-N-Octyl Phthalate		< 10	ug/l
0830 1,2-Diphenylhydrazine(Azobz)		< 10	ug/l
0831 Fluoranthene		< 10	ug/l
0832 Fluorene		< 10	ug/l
0833 Hexachlorobenzene		< 10	ug/l
0834 Hexachlorobutadiene		< 10	ug/l
0835 Hexachloro-cyclopentadiene		< 10	ug/l
0836 Hexachloroethane		< 10	ug/l
0837 Indeno(1,2,3 cd)Pyrene		< 10	ug/l
0838 Isophorone		< 10	ug/l
0839 Naphthalene		< 10	ug/l
0840 Nitrobenzene		< 10	ug/l
0841 N-Nitrosodimethylamine		< 10	ug/l
0842 N-Nitrosodi-N-Propylamine		< 10	ug/l
0843 N-Nitrosodiphenylamine		< 10	ug/l
0844 Phenanthrene		< 10	ug/l
0845 Pyrene		< 10	ug/l
0846 1,2,4-Trichlorobenzene		< 10	ug/l
0E25 Base Neutral Extraction-Water			N/A
0G36 GC/MS Additional Identification			
W310 RCRA GROUNDWATER-CONTAMINATION			
W100 Carbon, organic (C)		23	ug/l
W315 Halogens, Total Organic (TOX)		280	ug/l
W490 pH		6.6	
W700 Specific Conductance @ 25 C		7,200	uamhos/cm

WELL 2 (DENKA)

12/05

23120215

0110 VOLATILES-PP IN WATER

0V01 Acrolein

< 100 ug/l



Laboratory Services Division
900 Gemini Avenue
Houston, TX 77058

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713-488-1810

LAB ANALYSIS REPORT

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ADDRESS: 10701 CORPORATE DRIVE, SUIT 282
STAFFORD, TX 77477

MUS PROJECT NO: 000000
MUS CLIENT NO: 721501

REPORT DATE: 12/28/83

ATTENTION: WAYNE S. POLLARD

DATE RECEIVED: 12/06/83

SAMPLE IDENTIFICATION

	NUS SAMPLE NO	RESULTS	UNITS
OV02	Acrylonitrile	< 100	ug/l
OV03	Benzene	24	ug/l
OV05	Bromoform	< 10	ug/l
OV06	Carbon Tetrachloride	< 10	ug/l
OV07	Chlorobenzene	< 10	ug/l
OV08	Chlorodibromomethane	< 10	ug/l
OV09	Chloroethane	< 10	ug/l
OV10	2-Chloroethylvinyl Ether	< 10	ug/l
OV11	Chloroform	< 10	ug/l
OV12	Dichlorobromomethane	< 10	ug/l
OV14	1,1-Dichloroethane	< 10	ug/l
OV15	1,2-Dichloroethane	< 10	ug/l
OV16	1,1-Dichloroethylene	< 10	ug/l
OV17	1,2-Dichloropropane	< 10	ug/l
OV18	1,3-Dichloropropylene	< 10	ug/l
OV19	Ethylbenzene	13	ug/l
OV20	Methyl Bromide	< 10	ug/l
OV21	Methyl Chloride	< 10	ug/l
OV22	Methylene Chloride	< 10	ug/l
OV23	1,1,2,2-Tetrachloroethane	< 10	ug/l
OV24	Tetrachloroethylene(Perchloro)	< 10	ug/l
OV25	Toluene	39	ug/l
OV26	1,2-Trans-Dichloroethylene	< 10	ug/l
OV27	1,1,1-Trichloroethane	< 10	ug/l
OV28	1,1,2-Trichloroethane	< 10	ug/l
OV29	Trichloroethylene	< 10	ug/l
OV31	Vinyl chloride	< 10	ug/l
0120	ACIDS - PP IN WATER		
0A01	2-Chlorophenol	< 10	ug/l
0A02	2,4-Dichlorophenol	< 10	ug/l
0A03	2,4-Diethylphenol	< 10	ug/l
0A04	4,6-Dinitro-o-cresol	< 10	ug/l
0A05	2,4-Dinitrophenol	< 10	ug/l
0A06	2-Nitrophenol	< 10	ug/l



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REPORT DATE: 12/28/83

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DATE RECEIVED: 12/06/83

SAMPLE IDENTIFICATION

SAMPLE NO	RESULTS	UNITS
0A07 4-Nitrophenol	< 10	ug/l
0A08 p-Chloro-m-cresol	< 10	ug/l
0A09 Pentachlorophenol	< 10	ug/l
0A10 Phenol	< 10	ug/l
0A11 2,4,6-Trichlorophenol	< 10	ug/l
0E30 Acid Extraction-Water		
0130 BASE NEUTRALS - PP IN WATER		
0B01 Acenaphthene	< 10	ug/l
0B02 Acenaphthylene	< 10	ug/l
0B03 Anthracene	< 10	ug/l
0B04 Benzidine	< 10	ug/l
0B05 Benzo(a)Anthracene	< 10	ug/l
0B06 Benzo(a)Pyrene	< 10	ug/l
0B07 3,4-Benzofluoranthene	< 10	ug/l
0B08 Benzo(ghi)Perylene	< 10	ug/l
0B09 Benzo(k)Fluoranthene	< 10	ug/l
0B10 Bis(2-Chloroethoxy)Methane	< 10	ug/l
0B11 Bis(2-Chloroethyl)Ether	< 10	ug/l
0B12 Bis(2-Chloroisopropyl)Ether	< 10	ug/l
0B13 Bis(2-Ethylhexyl)Phthalate	27	ug/l
0B14 4-Bromophenyl Phenyl Ether	< 10	ug/l
0B15 Butyl Benzyl Phthalate	< 10	ug/l
0B16 2-Chloronaphthalene	< 10	ug/l
0B17 4-Chlorophenyl Phenyl Ether	< 10	ug/l
0B18 Chrysene	< 10	ug/l
0B19 Dibenzo(a,h)Anthracene	< 25	ug/l
0B20 1,2-Dichlorobenzene	< 10	ug/l
0B21 1,3-Dichlorobenzene	< 10	ug/l
0B22 1,4-Dichlorobenzene	< 10	ug/l
0B23 3,3'-Dichlorobenzidine	< 10	ug/l
0B24 Diethyl Phthalate	< 10	ug/l
0B25 Dimethyl Phthalate	< 10	ug/l
0B26 Di-N-Butyl Phthalate	< 10	ug/l
0B27 2,4-Dinitrotoluene	< 10	ug/l



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DATE RECEIVED: 12/06/83

SAMPLE IDENTIFICATION

NUS SAMPLE NO

RESULTS

UNITS

0828	2,6-Dinitrotoluene	< 10	ug/l
0829	Di-N-Octyl Phthalate	< 10	ug/l
0830	1,2-Diphenylhydrazine(Azobz)	< 10	ug/l
0831	Fluoranthene	< 10	ug/l
0832	Fluorene	< 10	ug/l
0833	Hexachlorbenzene	< 10	ug/l
0834	Hexachlorobutadiene	< 10	ug/l
0835	Hexachloro-cyclopentadiene	< 10	ug/l
0836	Hexachloroethane	< 10	ug/l
0837	Indeno(1,2,3 cd)Pyrene	< 10	ug/l
0838	Isophorone	< 10	ug/l
0839	Naphthalene	< 10	ug/l
0840	Nitrobenzene	< 10	ug/l
0841	N-Nitrosodimethylamine	< 10	ug/l
0842	N-Nitrosodi-N-Propylamine	< 10	ug/l
0843	N-Nitrosodiphenylamine	< 10	ug/l
0844	Phenanthrene	< 10	ug/l
0845	Pyrene	< 10	ug/l
0846	1,2,4-Trichlorobenzene	< 10	ug/l
0E25	Base Neutral Extraction-Water		
0G36	GC/MS Additional Identification		N/A
W310	RCRA GROUNDWATER-CONTAMINATION		
W100	Carbon, organic (C)	38	mg/l
W315	Halogens, Total Organic (TOX)	1000	ug/l
W490	pH	6.3	
W700	Specific Conductance @ 25 C	7,800	umhos/cm

WELL 3 (DEWKA)

12/05

23120216

0110 VOLATILES-PP IN WATER

0V01	Acrolein	< 100	ug/l
0V02	Acrylonitrile	< 100	ug/l
0V03	Benzene	< 10	ug/l
0V05	Bromoform	< 10	ug/l
0V06	Carbon Tetrachloride	< 10	ug/l



Laboratory Services Division
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713-488-1810

LAB ANALYSIS REPORT

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ADDRESS: 10701 CORPORATE DRIVE, SUIT 282
STAFFORD, TX 77477

NUS PROJECT NO: 000000
NUS CLIENT NO: 721501

REPORT DATE: 12/28/83

ATTENTION: WAYNE S. POLLARD

DATE RECEIVED: 12/06/83

SAMPLE IDENTIFICATION	NUS SAMPLE NO	RESULTS	UNITS
OV07 Chlorobenzene		< 10	ug/l
OV08 Chlorodibromomethane		< 10	ug/l
OV09 Chloroethane		< 10	ug/l
OV10 2-Chloroethylvinyl Ether		< 10	ug/l
OV11 Chloroform		< 10	ug/l
OV12 Dichlorobromomethane		< 10	ug/l
OV14 1,1-Dichloroethane		< 10	ug/l
OV15 1,2-Dichloroethane		< 10	ug/l
OV16 1,1-Dichloroethylene		< 10	ug/l
OV17 1,2-Dichloropropane		< 10	ug/l
OV18 1,3-Dichloropropylene		< 10	ug/l
OV19 Ethylbenzene		< 10	ug/l
OV20 Methyl Bromide		< 10	ug/l
OV21 Methyl Chloride		< 10	ug/l
OV22 Methylene Chloride		< 10	ug/l
OV23 1,1,2,2-Tetrachloroethane		< 10	ug/l
OV24 Tetrachloroethylene(Perchloro)		< 10	ug/l
OV25 Toluene		< 10	ug/l
OV26 1,2-Trans-Dichloroethylene		< 10	ug/l
OV27 1,1,1-Trichloroethane		< 10	ug/l
OV28 1,1,2-Trichloroethane		< 10	ug/l
OV29 Trichloroethylene		240	ug/l
OV31 Vinyl chloride		< 10	ug/l
Q120 ACIDS - PP IN WATER			
QA01 2-Chlorophenol		< 10	ug/l
QA02 2,4-Dichlorophenol		< 10	ug/l
QA03 2,4-Dimethylphenol		< 10	ug/l
QA04 4,6-Dinitro-o-cresol		< 10	ug/l
QA05 2,4-Dinitrophenol		< 10	ug/l
QA06 2-Nitrophenol		< 10	ug/l
QA07 4-Nitrophenol		< 10	ug/l
QA08 p-Chloro-m-cresol		< 10	ug/l
QA09 Pentachlorophenol		< 10	ug/l
QA10 Phenol		< 10	ug/l



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REPORT DATE: 12/28/83

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DATE RECEIVED: 12/06/83

SAMPLE IDENTIFICATION

NUS SAMPLE NO

RESULTS

UNITS

0A11	2,4,6-Trichlorophenol	(10	ug/l
0E30	Acid Extraction-Water		
0130	BASE NEUTRALS - PP IN WATER		
0B01	Acenaphthene	(10	ug/l
0B02	Acenaphthylene	(10	ug/l
0B03	Anthracene	(10	ug/l
0B04	Benzidine	(10	ug/l
0B05	Benzo(a)Anthracene	(10	ug/l
0B06	Benzo(a)Pyrene	(10	ug/l
0B07	3,4-Benzofluoranthene	(10	ug/l
0B08	Benzo(ghi)Perylene	(10	ug/l
0B09	Benzo(k)Fluoranthene	(10	ug/l
0B10	Bis(2-Chloroethoxy)Methane	(10	ug/l
0B11	Bis(2-Chloroethyl)Ether	(10	ug/l
0B12	Bis(2-Chloroisopropyl)Ether	(10	ug/l
0B13	Bis(2-Ethylhexyl)Phthalate	(10	ug/l
0B14	4-Bromophenyl Phenyl Ether	(10	ug/l
0B15	Butyl Benzyl Phthalate	(10	ug/l
0B16	2-Chloronaphthalene	(10	ug/l
0B17	4-Chlorophenyl Phenyl Ether	(10	ug/l
0B18	Chrysene	(10	ug/l
0B19	Dibenzo(a,h)Anthracene	(10	ug/l
0B20	1,2-Dichlorobenzene	(10	ug/l
0B21	1,3-Dichlorobenzene	(10	ug/l
0B22	1,4-Dichlorobenzene	(10	ug/l
0B23	3,3'-Dichlorobenzidine	(10	ug/l
0B24	Diethyl Phthalate	(10	ug/l
0B25	Dimethyl Phthalate	(10	ug/l
0B26	Di-N-Butyl Phthalate	(10	ug/l
0B27	2,4-Dinitrotoluene	(10	ug/l
0B28	2,6-Dinitrotoluene	(10	ug/l
0B29	Di-N-Octyl Phthalate	(10	ug/l
0B30	1,2-Diphenylhydrazine(Azobz)	(10	ug/l
0B31	Fluoranthene	(10	ug/l



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MUS PROJECT NO: 000000
MUS CLIENT NO: 721501

REPORT DATE: 12/28/83

ATTENTION: WAYNE S. POLLARD

DATE RECEIVED: 12/06/83

SAMPLE IDENTIFICATION

MUS SAMPLE NO

RESULTS

UNITS

0832	Fluorene	< 10	ug/l
0833	Hexachlorbenzene	< 10	ug/l
0834	Hexachlorobutadiene	< 10	ug/l
0835	Hexachloro-cyclopentadiene	< 10	ug/l
0836	Hexachloroethane	< 10	ug/l
0837	Indeno(1,2,3 cd)Pyrene	< 10	ug/l
0838	Isophorone	< 10	ug/l
0839	Naphthalene	< 10	ug/l
0840	Nitrobenzene	< 10	ug/l
0841	N-Nitrosodimethylamine	< 10	ug/l
0842	N-Nitrosodi-N-Propylamine	< 10	ug/l
0843	N-Nitrosodiphenylamine	< 10	ug/l
0844	Phenanthrene	< 10	ug/l
0845	Pyrene	< 10	ug/l
0846	1,2,4-Trichlorobenzene	< 10	ug/l
0E25	Base Neutral Extraction-Water		
0G36	GC/MS Additional Identification		N/A
W310	RCRA GROUNDWATER-CONTAMINATION		
W100	Carbon, organic (C)	11	ug/l
W315	Halogens, Total Organic (TOX)	170	ug/l
W490	pH	6.4	
W700	Specific Conductance @ 25 C	2,900	uamhos/cm

WELL #4 (DENKA)

12/05

23120217

0110 VOLATILES-PP IN WATER

0V01	Acrolein	< 100	ug/l
0V02	Acrylonitrile	< 100	ug/l
0V03	Benzene	< 10	ug/l
0V05	Bromoform	< 10	ug/l
0V06	Carbon Tetrachloride	< 10	ug/l
0V07	Chlorobenzene	< 10	ug/l
0V08	Chlorodibromomethane	< 10	ug/l
0V09	Chloroethane	< 10	ug/l
0V10	2-Chloroethylvinyl Ether	< 10	ug/l



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REPORT DATE: 12/28/83

ATTENTION: WAYNE S. POLLARD

DATE RECEIVED: 12/06/83

SAMPLE IDENTIFICATION	NUS SAMPLE NO	RESULTS	UNITS
OV11 Chloroform		< 10	ug/l
OV12 Dichlorobromomethane		< 10	ug/l
OV14 1,1-Dichloroethane		< 10	ug/l
OV15 1,2-Dichloroethane		< 10	ug/l
OV16 1,1-Dichloroethylene		< 10	ug/l
OV17 1,2-Dichloropropane		< 10	ug/l
OV18 1,3-Dichloropropylene		< 10	ug/l
OV19 Ethylbenzene		< 10	ug/l
OV20 Methyl Bromide		< 10	ug/l
OV21 Methyl Chloride		< 10	ug/l
OV22 Methylene Chloride		10	ug/l
OV23 1,1,2,2-Tetrachloroethane		< 10	ug/l
OV24 Tetrachloroethylene(Perchloro)		< 10	ug/l
OV25 Toluene		< 10	ug/l
OV26 1,2-Trans-Dichloroethylene		< 10	ug/l
OV27 1,1,1-Trichloroethane		< 10	ug/l
OV28 1,1,2-Trichloroethane		< 10	ug/l
OV29 Trichloroethylene		240	ug/l
OV31 Vinyl chloride		< 10	ug/l
0120 ACIDS - PP IN WATER			
OA01 2-Chlorophenol		< 10	ug/l
OA02 2,4-Dichlorophenol		< 10	ug/l
OA03 2,4-Dimethylphenol		< 10	ug/l
OA04 4,6-Dinitro-o-cresol		< 10	ug/l
OA05 2,4-Dinitrophenol		< 10	ug/l
OA06 2-Nitrophenol		< 10	ug/l
OA07 4-Nitrophenol		< 10	ug/l
OA08 p-Chloro-o-cresol		< 10	ug/l
OA09 Pentachlorophenol		< 10	ug/l
OA10 Phenol		< 10	ug/l
OA11 2,4,6-Trichlorophenol		< 10	ug/l
OE30 Acid Extraction-Water			
0130 BASE NEUTRALS - PP IN WATER			
OB01 Acenaphthene		< 10	ug/l



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DATE RECEIVED: 12/06/83

SAMPLE IDENTIFICATION

NUS SAMPLE NO

RESULTS

UNITS

0802	Acenaphthylene	< 10	ug/l
0803	Anthracene	< 10	ug/l
0804	Benzidine	< 10	ug/l
0805	Benzo(a)Anthracene	< 10	ug/l
0806	Benzo(a)Pyrene	< 10	ug/l
0807	3,4-Benzofluoranthene	< 10	ug/l
0808	Benzo(ghi)Perylene	< 10	ug/l
0809	Benzo(k)Fluoranthene	< 10	ug/l
0810	Bis(2-Chloroethoxy)Methane	< 10	ug/l
0811	Bis(2-Chloroethyl)Ether	< 10	ug/l
0812	Bis(2-Chloroisopropyl)Ether	< 10	ug/l
0813	Bis(2-Ethylhexyl)Phthalate	52	ug/l
0814	4-Bromophenyl Phenyl Ether	< 10	ug/l
0815	Butyl Benzyl Phthalate	< 10	ug/l
0816	2-Chloronaphthalene	< 10	ug/l
0817	4-Chlorophenyl Phenyl Ether	< 10	ug/l
0818	Chrysene	< 10	ug/l
0819	Dibenzo(a,h)Anthracene	< 10	ug/l
0820	1,2-Dichlorobenzene	< 10	ug/l
0821	1,3-Dichlorobenzene	< 10	ug/l
0822	1,4-Dichlorobenzene	< 10	ug/l
0823	3,3'-Dichlorobenzidine	< 10	ug/l
0824	Diethyl Phthalate	< 10	ug/l
0825	Dimethyl Phthalate	< 10	ug/l
0826	Di-N-Butyl Phthalate	< 10	ug/l
0827	2,4-Dinitrotoluene	< 10	ug/l
0828	2,6-Dinitrotoluene	< 10	ug/l
0829	Di-N-Octyl Phthalate	< 10	ug/l
0830	1,2-Diphenylhydrazine(Azobz)	< 10	ug/l
0831	Fluoranthene	< 10	ug/l
0832	Fluorene	< 10	ug/l
0833	Hexachlorbenzene	< 10	ug/l
0834	Hexachlorobutadiene	< 10	ug/l
0835	Hexachloro-cyclopentadiene	< 10	ug/l



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MUS PROJECT NO: 000000
MUS CLIENT NO: 721501

REPORT DATE: 12/28/83

ATTENTION: WAYNE S. POLLARD

DATE RECEIVED: 12/06/83

SAMPLE IDENTIFICATION

SAMPLE IDENTIFICATION	MUS SAMPLE NO	RESULTS	UNITS
0836 Hexachloroethane		< 10	ug/l
0837 Indeno(1,2,3 cd)Pyrene		< 10	ug/l
0838 Isophorone		< 10	ug/l
0839 Naphthalene		< 10	ug/l
0840 Nitrobenzene		< 10	ug/l
0841 N-Nitrosodiaethylamine		< 10	ug/l
0842 N-Nitrosodi-N-Propylamine		< 10	ug/l
0843 N-Nitrosodiphenylamine		< 10	ug/l
0844 Phenanthrene		< 10	ug/l
0845 Pyrene		< 10	ug/l
0846 1,2,4-Trichlorobenzene		< 10	ug/l
0E25 Base Neutral Extraction-Water			N/A
GG36 GC/MS Additional Identification			
W310 RCRA GROUNDWATER-CONTAMINATION			
W100 Carbon, organic (C)		7	ug/l
W315 Halogens, Total Organic (TOX)		620	ug/l
W490 pH		7.0	
W700 Specific Conductance @ 25 C		1,200	uohms/cm

WELL 5A (DEWKA)

12/05

23120218

0110 VOLATILES-PP IN WATER

OV01 Acrolein	< 100	ug/l
OV02 Acrylonitrile	< 100	ug/l
OV03 Benzene	< 10	ug/l
OV05 Bromoform	< 10	ug/l
OV06 Carbon Tetrachloride	< 10	ug/l
OV07 Chlorobenzene	< 10	ug/l
OV08 Chlorodibromomethane	< 10	ug/l
OV09 Chloroethane	< 10	ug/l
OV10 2-Chloroethylvinyl Ether	< 10	ug/l
OV11 Chloroform	< 10	ug/l
OV12 Dichlorobromomethane	< 10	ug/l
OV14 1,1-Dichloroethane	< 10	ug/l
OV15 1,2-Dichloroethane	< 10	ug/l



Laboratory Services Division
900 Gemini Avenue
Houston, TX 77058

REMIT TO:
900 Gemini Avenue
Houston, TX 77058
713-488-1810

LAB ANALYSIS REPORT

CLIENT NAME: GEO-ASSOCIATES
ADDRESS: 10701 CORPORATE DRIVE, SUIT 282
STAFFORD, TX 77477

MUS PROJECT NO: 000000
MUS CLIENT NO: 721501

REPORT DATE: 12/28/83

ATTENTION: WAYNE S. POLLARD

DATE RECEIVED: 12/06/83

SAMPLE IDENTIFICATION	MUS SAMPLE NO	RESULTS	UNITS
OV16 1,1-Dichloroethylene		< 10	ug/l
OV17 1,2-Dichloropropane		< 10	ug/l
OV18 1,3-Dichloropropylene		< 10	ug/l
OV19 Ethylbenzene		< 10	ug/l
OV20 Methyl Bromide		< 10	ug/l
OV21 Methyl Chloride		< 10	ug/l
OV22 Methylene Chloride		< 10	ug/l
OV23 1,1,2,2-Tetrachloroethane		10	ug/l
OV24 Tetrachloroethylene(Perchloro)		< 10	ug/l
OV25 Toluene		< 10	ug/l
OV26 1,2-Trans-Dichloroethylene		< 10	ug/l
OV27 1,1,1-Trichloroethane		< 10	ug/l
OV28 1,1,2-Trichloroethane		< 10	ug/l
OV29 Trichloroethylene		< 10	ug/l
OV31 Vinyl chloride		< 10	ug/l
0120 ACIDS - PP IN WATER			
OA01 2-Chlorophenol		< 10	ug/l
OA02 2,4-Dichlorophenol		< 10	ug/l
OA03 2,4-Dimethylphenol		< 10	ug/l
OA04 4,6-Dinitro-o-cresol		< 10	ug/l
OA05 2,4-Dinitrophenol		< 10	ug/l
OA06 2-Nitrophenol		< 10	ug/l
OA07 4-Nitrophenol		< 10	ug/l
OA08 p-Chloro-a-cresol		< 10	ug/l
OA09 Pentachlorophenol		< 10	ug/l
OA10 Phenol		< 10	ug/l
OA11 2,4,6-Trichlorophenol		< 10	ug/l
OE30 Acid Extraction-Water			
0130 BASE NEUTRALS - PP IN WATER			
OB01 Acenaphthene		< 10	ug/l
OB02 Acenaphthylene		< 10	ug/l
OB03 Anthracene		< 10	ug/l
OB04 Benzidine		< 10	ug/l
OB05 Benzo(a)Anthracene		< 10	ug/l



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REPORT DATE: 12/28/83

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SAMPLE IDENTIFICATION

NUS SAMPLE NO RESULTS UNITS

0806	Benzo(a)Pyrene	< 10	ug/l
0807	3,4-Benzofluoranthene	< 10	ug/l
0808	Benzo(ghi)Perylene	< 10	ug/l
0809	Benzo(k)Fluoranthene	< 10	ug/l
0810	Bis(2-Chloroethoxy)Methane	< 10	ug/l
0811	Bis(2-Chloroethyl)Ether	< 10	ug/l
0812	Bis(2-Chloroisopropyl)Ether	< 10	ug/l
0813	Bis(2-Ethylhexyl)Phthalate	15	ug/l
0814	4-Bromophenyl Phenyl Ether	< 10	ug/l
0815	Butyl Benzyl Phthalate	< 10	ug/l
0816	2-Chloronaphthalene	< 10	ug/l
0817	4-Chlorophenyl Phenyl Ether	< 10	ug/l
0818	Chrysene	< 10	ug/l
0819	Dibenzo(a,h)Anthracene	< 10	ug/l
0820	1,2-Dichlorobenzene	< 10	ug/l
0821	1,3-Dichlorobenzene	< 10	ug/l
0822	1,4-Dichlorobenzene	< 10	ug/l
0823	3,3'-Dichlorobenzidine	< 10	ug/l
0824	Diethyl Phthalate	< 10	ug/l
0825	Dimethyl Phthalate	< 10	ug/l
0826	Di-N-Butyl Phthalate	< 10	ug/l
0827	2,4-Dinitrotoluene	< 10	ug/l
0828	2,6-Dinitrotoluene	< 10	ug/l
0829	Di-N-Octyl Phthalate	< 10	ug/l
0830	1,2-Diphenylhydrazine(Azobz)	< 10	ug/l
0831	Fluoranthene	< 10	ug/l
0832	Fluorene	< 10	ug/l
0833	Hexachlorobenzene	< 10	ug/l
0834	Hexachlorobutadiene	< 10	ug/l
0835	Hexachloro-cyclopentadiene	< 10	ug/l
0836	Hexachloroethane	< 10	ug/l
0837	Indeno(1,2,3 cd)Pyrene	< 10	ug/l
0838	Isophorone	< 10	ug/l
0839	Naphthalene	< 10	ug/l



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SAMPLE IDENTIFICATION

NUS SAMPLE NO

RESULTS

UNITS

0840	Nitrobenzene	< 10	ug/l
0841	N-Nitrosodimethylamine	< 10	ug/l
0842	N-Nitrosodi-N-Propylamine	< 10	ug/l
0843	N-Nitrosodiphenylamine	< 10	ug/l
0844	Phenanthrene	< 10	ug/l
0845	Pyrene	< 10	ug/l
0846	1,2,4-Trichlorobenzene	< 10	ug/l
0825	Base Neutral Extraction-Water		
0836	GC/MS Additional Identificatio		N/A
W310	RCRA GROUNDWATER-CONTAMINATION		
W100	Carbon, organic (C)	8	ug/l
W315	Halogens, Total Organic (TOX)	260	ug/l
W490	pH	6.7	
W700	Specific Conductance @ 25 C	5,300	uohms/cm
21 (DENKA)			
	12/05	23120219	
0110	VOLATILES-PP IN WATER		
0V01	Acrolein	< 100	ug/l
0V02	Acrylonitrile	< 100	ug/l
0V03	Benzene	< 10	ug/l
0V05	Bromoform	< 10	ug/l
0V06	Carbon Tetrachloride	< 10	ug/l
0V07	Chlorobenzene	< 10	ug/l
0V08	Chlorodibromomethane	< 10	ug/l
0V09	Chloroethane	< 10	ug/l
0V10	2-Chloroethylvinyl Ether	< 10	ug/l
0V11	Chloroform	< 10	ug/l
0V12	Dichlorobromomethane	< 10	ug/l
0V14	1,1-Dichloroethane	< 10	ug/l
0V15	1,2-Dichloroethane	< 10	ug/l
0V16	1,1-Dichloroethylene	< 10	ug/l
0V17	1,2-Dichloropropane	< 10	ug/l
0V18	1,3-Dichloropropylene	< 10	ug/l
0V19	Ethylbenzene	< 10	ug/l



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SAMPLE IDENTIFICATION	NUS SAMPLE NO	RESULTS	UNITS
OV20 Methyl Bromide		< 10	ug/l
OV21 Methyl Chloride		< 10	ug/l
OV22 Methylene Chloride		< 10	ug/l
OV23 1,1,2,2-Tetrachloroethane		< 10	ug/l
OV24 Tetrachloroethylene(Perchloro)		< 10	ug/l
OV25 Toluene		< 10	ug/l
OV26 1,2-Trans-Dichloroethylene		< 10	ug/l
OV27 1,1,1-Trichloroethane		< 10	ug/l
OV28 1,1,2-Trichloroethane		< 10	ug/l
OV29 Trichloroethylene		< 10	ug/l
OV31 Vinyl chloride		< 10	ug/l
Q120 ACIDS - PP IN WATER			
QA01 2-Chlorophenol		< 10	ug/l
QA02 2,4-Dichlorophenol		< 10	ug/l
QA03 2,4-Diethylphenol		< 10	ug/l
QA04 4,6-Dinitro-o-cresol		< 10	ug/l
QA05 2,4-Dinitrophenol		< 10	ug/l
QA06 2-Nitrophenol		< 10	ug/l
QA07 4-Nitrophenol		< 10	ug/l
QA08 p-Chloro-m-cresol		< 10	ug/l
QA09 Pentachlorophenol		< 10	ug/l
QA10 Phenol		< 10	ug/l
QA11 2,4,6-Trichlorophenol		< 10	ug/l
DE30 Acid Extraction-Water			
Q130 BASE NEUTRALS - PP IN WATER			
OB01 Acenaphthene		< 10	ug/l
OB02 Acenaphthylene		< 10	ug/l
OB03 Anthracene		< 10	ug/l
OB04 Benzidine		< 10	ug/l
OB05 Benzo(a)Anthracene		< 10	ug/l
OB06 Benzo(a)Pyrene		< 10	ug/l
OB07 3,4-Benzofluoranthene		< 10	ug/l
OB08 Benzo(ghi)Perylene		< 10	ug/l
OB09 Benzo(k)Fluoranthene		< 10	ug/l



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SAMPLE IDENTIFICATION

MUS SAMPLE NO

RESULTS

UNITS

0810	Bis(2-Chloroethoxy)Methane	< 10	ug/l
0811	Bis(2-Chloroethyl)Ether	< 10	ug/l
0812	Bis(2-Chloroisopropyl)Ether	< 10	ug/l
0813	Bis(2-Ethylhexyl)Phthalate	< 10	ug/l
0814	4-Bromophenyl Phenyl Ether	< 10	ug/l
0815	Butyl Benzyl Phthalate	< 10	ug/l
0816	2-Chloronaphthalene	< 10	ug/l
0817	4-Chlorophenyl Phenyl Ether	< 10	ug/l
0818	Chrysene	< 10	ug/l
0819	Dibenzo(a,h)Anthracene	< 10	ug/l
0820	1,2-Dichlorobenzene	< 10	ug/l
0821	1,3-Dichlorobenzene	< 10	ug/l
0822	1,4-Dichlorobenzene	< 10	ug/l
0823	3,3'-Dichlorobenzidine	< 10	ug/l
0824	Diethyl Phthalate	< 10	ug/l
0825	Dimethyl Phthalate	< 10	ug/l
0826	Di-N-Butyl Phthalate	< 10	ug/l
0827	2,4-Dinitrotoluene	< 10	ug/l
0828	2,6-Dinitrotoluene	< 10	ug/l
0829	Di-N-Octyl Phthalate	< 10	ug/l
0830	1,2-Diphenylhydrazine(Azobz)	< 10	ug/l
0831	Fluoranthene	< 10	ug/l
0832	Fluorene	< 10	ug/l
0833	Hexachlorobenzene	< 10	ug/l
0834	Hexachlorobutadiene	< 10	ug/l
0835	Hexachloro-cyclopentadiene	< 10	ug/l
0836	Hexachloroethane	< 10	ug/l
0837	Indeno(1,2,3 cd)Pyrene	< 10	ug/l
0838	Isophorone	< 10	ug/l
0839	Naphthalene	< 10	ug/l
0840	Nitrobenzene	< 10	ug/l
0841	N-Nitrosodimethylamine	< 10	ug/l
0842	N-Nitrosodi-N-Propylamine	< 10	ug/l
0843	N-Nitrosodiphenylamine	< 10	ug/l



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DATE RECEIVED: 12/06/83

SAMPLE IDENTIFICATION

NUS SAMPLE NO	RESULTS	UNITS
0844 Phenanthrene	< 10	ug/l
0845 Pyrene	< 10	ug/l
0846 1,2,4-Trichlorobenzene	< 10	ug/l
0E25 Base Neutral Extraction-Water		
0G36 GC/MS Additional Identification		N/A
W310 RCRA GROUNDWATER-CONTAMINATION		
W100 Carbon, organic (C)	3	ug/l
W315 Halogens, Total Organic (TOX)	44	ug/l
W490 pH	7.1	
W700 Specific Conductance @ 25 C	1,900	umhos/cm

22 (DENKA)

12/05

23120220

0110 VOLATILES-PP IN WATER

0V01 Acrolein	< 100	ug/l
0V02 Acrylonitrile	< 100	ug/l
0V03 Benzene	< 10	ug/l
0V05 Bromoform	< 10	ug/l
0V06 Carbon Tetrachloride	< 10	ug/l
0V07 Chlorobenzene	< 10	ug/l
0V08 Chlorodibromomethane	< 10	ug/l
0V09 Chloroethane	< 10	ug/l
0V10 2-Chloroethylvinyl Ether	< 10	ug/l
0V11 Chloroform	< 10	ug/l
0V12 Dichlorobromomethane	< 10	ug/l
0V14 1,1-Dichloroethane	< 10	ug/l
0V15 1,2-Dichloroethane	< 10	ug/l
0V16 1,1-Dichloroethylene	< 10	ug/l
0V17 1,2-Dichloropropane	< 10	ug/l
0V18 1,3-Dichloropropylene	< 10	ug/l
0V19 Ethylbenzene	< 10	ug/l
0V20 Methyl Bromide	< 10	ug/l
0V21 Methyl Chloride	< 10	ug/l
0V22 Methylene Chloride	< 10	ug/l
0V23 1,1,2,2-Tetrachloroethane	< 10	ug/l



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SAMPLE IDENTIFICATION

NUS SAMPLE NO RESULTS UNITS

OV24	Tetrachloroethylene(Perchloro)	< 10	ug/l
OV25	Toluene	< 10	ug/l
OV26	1,2-Trans-Dichloroethylene	< 10	ug/l
OV27	1,1,1-Trichloroethane	< 10	ug/l
OV28	1,1,2-Trichloroethane	< 10	ug/l
OV29	Trichloroethylene	< 10	ug/l
OV31	Vinyl chloride	< 10	ug/l
0120	ACIDS - PP IN WATER		
OA01	2-Chlorophenol	< 10	ug/l
OA02	2,4-Dichlorophenol	< 10	ug/l
OA03	2,4-Dimethylphenol	< 10	ug/l
OA04	4,6-Dinitro-o-cresol	< 10	ug/l
OA05	2,4-Dinitrophenol	< 10	ug/l
OA06	2-Nitrophenol	< 10	ug/l
OA07	4-Nitrophenol	< 10	ug/l
OA08	p-Chloro-m-cresol	< 10	ug/l
OA09	Pentachlorophenol	< 10	ug/l
OA10	Phenol	< 10	ug/l
OA11	2,4,6-Trichlorophenol	< 10	ug/l
DE30	Acid Extraction-Water		
0130	BASE NEUTRALS - PP IN WATER		
OB01	Acenaphthene	< 10	ug/l
OB02	Acenaphthylene	< 10	ug/l
OB03	Anthracene	< 10	ug/l
OB04	Benzidine	< 10	ug/l
OB05	Benzo(a)Anthracene	< 10	ug/l
OB06	Benzo(a)Pyrene	< 10	ug/l
OB07	3,4-Benzofluoranthene	< 10	ug/l
OB08	Benzo(ghi)Perylene	< 10	ug/l
OB09	Benzo(k)Fluoranthene	< 10	ug/l
OB10	Bis(2-Chloroethoxy)Methane	< 10	ug/l
OB11	Bis(2-Chloroethyl)Ether	< 10	ug/l
OB12	Bis(2-Chloroisopropyl)Ether	< 10	ug/l
OB13	Bis(2-Ethylhexyl)Phthalate	81	ug/l



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SAMPLE IDENTIFICATION	NUS SAMPLE NO	RESULTS	UNITS
0814 4-Bromophenyl Phenyl Ether		< 10	ug/l
0815 Butyl Benzyl Phthalate		< 10	ug/l
0816 2-Chloronaphthalene		< 10	ug/l
0817 4-Chlorophenyl Phenyl Ether		< 10	ug/l
0818 Chrysene		< 10	ug/l
0819 Dibenzo(a,h)Anthracene		< 10	ug/l
0820 1,2-Dichlorobenzene		< 10	ug/l
0821 1,3-Dichlorobenzene		< 10	ug/l
0822 1,4-Dichlorobenzene		< 10	ug/l
0823 3,3'-Dichlorobenzidine		< 10	ug/l
0824 Diethyl Phthalate		< 10	ug/l
0825 Dimethyl Phthalate		< 10	ug/l
0826 Di-N-Butyl Phthalate		< 10	ug/l
0827 2,4-Dinitrotoluene		< 10	ug/l
0828 2,6-Dinitrotoluene		< 10	ug/l
0829 Di-N-Octyl Phthalate		< 10	ug/l
0830 1,2-Diphenylhydrazine(Azobz)		< 10	ug/l
0831 Fluoranthene		< 10	ug/l
0832 Fluorene		< 10	ug/l
0833 Hexachlorobenzene		< 10	ug/l
0834 Hexachlorobutadiene		< 10	ug/l
0835 Hexachloro-cyclopentadiene		< 10	ug/l
0836 Hexachloroethane		< 10	ug/l
0837 Indeno(1,2,3 cd)Pyrene		< 10	ug/l
0838 Isophorone		< 10	ug/l
0839 Naphthalene		< 10	ug/l
0840 Nitrobenzene		< 10	ug/l
0841 N-Nitrosodimethylamine		< 10	ug/l
0842 N-Nitrosodi-N-Propylamine		< 10	ug/l
0843 N-Nitrosodiphenylamine		< 10	ug/l
0844 Phenanthrene		< 10	ug/l
0845 Pyrene		< 10	ug/l
0846 1,2,4-Trichlorobenzene		< 10	ug/l
0E25 Base Neutral Extraction-Water			



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ATTENTION: WAYNE S. POLLARD

DATE RECEIVED: 12/06/83

SAMPLE IDENTIFICATION

NUS SAMPLE NO

RESULTS

UNITS

0636 GC/MS Additional Identification
W310 RCRA GROUNDWATER-CONTAMINATION
W100 Carbon, organic (C)
W315 Halogens, Total Organic (TOX)
W490 pH
W700 Specific Conductance @ 25 C

N/A

3

mg/l

27

ug/l

7.3

1,300

uahos/cm

COMMENTS: